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MINERAL LAND CLASSIFICATION: PORTLAND CEMENT CONCRETE-GRADE AGGREGATE IN THE YUBA CITY-MARYSVILLE PRODUCTION-CONSUMPTION REGION

1988

ALIFORNIA DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGY

SPECIAL REPORT 132

OURCES AGENCY
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RY FOR RESOURCES

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SPECIAL REPORT 132

MINERAL LAND CLASSIFICATION: PORTLAND CEMENT CONCRETE-GRADE AGGREGATE IN THE YUBA CITY-MARYSVILLE PRODUCTION-CONSUMPTION REGION

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1988

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FOREWORD

Special Report 132, "Mineral Land Classification: Portland Cement Concrete-Grade Aggregate in the Yuba City-Marysville Production-Consumption Region," is part of the continuing analysis of aggregate resources in California to be developed by the California Department of Conservation, Division of Mines and Geology under authority of the Surface Mining and Reclamation Act of 1975 (SMARA). This classification is provided to the State Mining and Geology Board for transmittal to the local governments that regulate land use in this region, and for consideration of areas, if any, to be designated as regionally significant. SMARA was enacted by the State Legislature to assure mineral resource conservation and adequate mined land reclamation.

The Mining and Geology Board adopted guidelines in June 1978 to be employed by the Division in its mineral resource classification. This report was prepared in conformance with those directives. The undertaking is of great importance in economic geology because it deals with very specific mineral resource conservation issues in areas of intensive competing land use.

PREFACE

Reserve tonnage data presented in this report was accurate as of January 1986. In August 1987, a preprint version of the report was circulated to lead agencies and made available to the public. Changes in reserves resulting from either the premature closure of mines active in 1985, or the permitting of new mines since that time, may have impacted forecasted depletion dates for the production-consumption region studied. However, the material presented and the fundamental conclusions of the report remain valid and useful.

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EXECUTIVE SUMMARY

This report presents the results of the classification of aggregate resources by the Division of Mines and Geology (DMG) in the Yuba City-Marysville Production-Consumption (P-C) Region. The primary goals of the study were:

1. To delineate, within the P-C region, all land containing sand and gravel deposits suitable for production as high-quality, Portland cement concrete (PCC) aggregate.
2. To calculate the quantity of the resources in these deposits that are on lands considered by the State to be available for possible aggregate production based upon evaluation of land uses.
3. To evaluate the adequacy of the current aggregate *reserves* (aggregate resources on land permitted for mining by local government) for meeting the future needs of the P-C region.

In the Yuba City-Marysville area, as in any urbanizing area, it is important that land-use decisions are made with full recognition of the natural resources of the region. This is especially true when the resource in question is high-grade construction aggregate which is an indispensable building material and costly to transport.

The Yuba City-Marysville area has been fortunate in that adequate quantities of low-cost, high-quality aggregate materials have been available locally. The P-C region has an estimated population of 74,000 and a growth rate between 1 and 2 percent annually. Because the available resource volume is so large, other surrounding areas which are rapidly urbanizing and have projected shortfalls of PCC aggregate, such as Sacramento and the San Francisco Bay area, could consider utilizing this deposit as an alternative resource.

The loss of regionally significant mineral deposits to land uses that preclude mining is one of the problems that the California Surface Mining and Reclamation Act of 1975 (SMARA) was framed to address. SMARA mandates a two-phased mineral resource conservation process called classification-designation. The objective of the classification-designation process is to provide information on resource availability to the urban population centers which depend upon it for future growth. This perspective will, it is hoped, provide a context for land-use decisions by local government within which mineral resource availability is acknowledged as a pertinent factor being balanced with other considerations.

The DMG is responsible under SMARA for carrying out the classification phase of the classification-designation process. Classification of land for aggregate resources in the Yuba City-Marysville area is presented in this report. The State Mining and Geology Board (the Board) is responsible for the second phase of SMARA. In this phase, the Board may designate areas within a P-C region that contain significant deposits of PCC-grade aggregate that may be needed to meet the State's or region's future demand. The Board's decision to designate an area is based upon information in the classification report prepared by DMG and input received from lead agencies and the public. Through designation, the Board provides formal recognition of regionally significant deposits of aggregate resources.

The California Department of Conservation's Division of Mines and Geology has classified approximately 145 square miles of land within the Yuba City-Marysville P-C Region according to the presence or absence of significant sand, gravel, or stone deposits that are suitable as sources of PCC-grade aggregate. If a deposit contained at least $5 million worth (in 1978 dollars) of suitable material that could be extracted and marketed profitably under present technologic conditions, or those which could be estimated to exist in the foreseeable future, the deposit was classified MRZ-2.

The land classification within the Yuba City-Marysville P-C Region is presented in the form of eight U.S. Geological Survey topographic quadrangle maps showing the Mineral Resource Zones (Plates 1-8). Mineral Resource Zones were established on the basis of a sand, gravel, and stone resource appraisal which included a study of pertinent geologic reports and maps, field investigations of outcrops and active and inactive quarries, and analysis of water-well logs and drill records.

The area classified as MRZ-2 in the Yuba River and its adjacent dredge tailings is subdivided by urbanization into several smaller areas that have been identified separately as sectors on Plates 9-11.

In order to organize the volume calculations of the aggregate resources, the State Geologist has developed the concept of "sectors" to identify those MRZ-2 areas that are available for future aggregate extraction. The sector concept is used for the convenience of arraying resource information, and is intended to convey accurate information regarding the locations and approximate tonnage of resources in nonurbanized areas.

In the Yuba City-Marysville P-C Region there are two major MRZ-2 areas (Sectors A and B), divided into 18 smaller areas (subsectors), with existing land uses that are compatible with mining. Together the sectors cover 22.8 square miles and contain a total of 2.25 billion tons

af PCC-grade aggregate. The identification af resource sectors has been dane ta inform lead agencies and others af aggregate resaurces that can be made available far mining by virtue of the present, generally undeveloped status af the land. The sectorization of any specific area is not an advocacy of mining in that area.

Reserves are aggregate materials that a sand and gravel campany owns or cantrals, and far which it has a valid mining permit. Resources are the total amount of available aggregate within an area, including reserves. The estimated aggregate resources within the two sectars amount to 2.25 billion tons; of this, 1.26 billion tans are identified as reserves available for mining at the end af 1985. The tatal projected aggregate consumptian within the P-C region to the year 2035 is estimated to be 26.5 million tons or twa percent of the tatal available reserves. Hawever, increased demand far this resaurce by the Sacramento and San Francisco Bay regions may result in a much higher rate of depletion.

Ta make the aggregate demand prajectian, praduction records and population figures far the Yuba City-Marysville P-C Regian were correlated for the past 20 years (1964-1984) ta obtain an average per capita rate of consumption. The derived rate of 5.4 tans per person per year was used along with papulatian projectians to make the estimate of the tatal P-C region consumption far the next 50 years. Should unforeseen events occur, such as massive urban renewal, disaster reconstruction, or major recessian, the aggregate demand cauld change cansiderably.

Possible alternative saurces of aggregate, in addition to those depasits classified as MRZ-2, are present within the Yuba City-Marysville P-C Regian. These possible alternative saurces include river channel depasits, parts of the Riverbank and Madesta formations, and volcanic, granodioritic, and metamorphic bedrack. All of these sources are classified MRZ-3 because toa little is known about their physical and chemical qualities ta permit even crude resaurce estimates. The enarmous tannage af aggregate reserves in the Yuba River and the dredge tailings, caupled with the relatively small local consumption, makes it unlikely that any af these alternative sources will need to be used in the fareseeable future.

As with many forecasts of ecanamic activity, the forecasts in this report should nat be viewed as offering unqualified predictians af how the future will unfold. The forecasts of this repart are based upon the assumption that the data base is accurate, and the development trends of the past twa decades will continue inta the 5 decades ahead.

Assuming, however, the correctness of our forecasts for the consumption of aggregate, the fallawing conclusions were reached:

- The anticipated consumption of aggregate resaurces in the P-C region to the year 2035 is forecast ta be 26.5 millian tans, af which appraximately 29 percent or 7.7 million tons must be of PCC quality.
- The aggregate resources within the P-C regian will be able ta supply the local area with PCC-grade aggregate past the year 2035.
- Abaut 1,262 million tons of permitted PCC-grade reserves exist in the P-C region. Of this tatal, 1,215 millian tons occur alang the Yuba River in the dredge tailings (Sectar A) and 46 million tons accur alang the Yuba River west af the dredge tailings and east af Marysville (Sectar B).
- In total, the 1,262 millian tans af permitted PCC-grade aggregate reserves amount ta many times the anticipated lacal cansumption of PCC aggregate during the next 50 years. The 50-year demand af total aggregate will consume only two percent of the total reserves for the P-C region.
- The expected langevity of the existing PCC-grade aggregate reserves is based upon the assumption that mining of these reserves will cantinue ta be permitted until the reserves are depleted.
- Should the P-C regian's 1,262 millian tans af PCC-grade aggregate reserves be used salely far PCC-grade aggregate, they would last well past the year 2035. Even if, as can be expected, much of the PCC-grade aggregate reserves will cantinue ta be used far nan-PCC uses, the reserves will still last well past the year 2035.
- 2.3 billian tons af PCC-grade aggregate resaurces (including reserves) have been identified in the Yuba City-Marysville P-C Regian.
- The Yuba City-Marysville P-C Regian covers an area of 145 square miles, of which 24.3 square miles (17 percent of the tatal area) were classified MRZ-2. Only 22.8 square miles (16 percent af the tatal area) have been sectorized as having current land uses which do not preclude mining. Appraximately 10.3 square miles (7 percent of the tatal area) af the sectorized area is currently under mining permits.
- The PCC aggregate needs af Yuba City-Marysville will be easily met by local deposits. However, neighboring areas such as Sacramenta and San Francisca are not as fortunate; Sacramento reserves are expected to be depleted as soon as 1991 and the South San Francisco Bay area reserves could be depleted as saan as 1999. Because of its large reserves and resaurces, the Yuba City-Marysville area could become a major source of PCC aggregate far the San Francisco and Sacramenta markets.

MINERAL LAND CLASSIFICATION: PORTLAND CEMENT CONCRETE-GRADE AGGREGATE IN THE YUBA CITY-MARYSVILLE PRODUCTION-CONSUMPTION REGION

INTRODUCTION

In the Yuba City-Marysville area (Figures 1 and 2), as in any urbanizing area, it is important that land-use decisions are made with full recognition of the natural resources of the area. This is especially true when the resource in question is high-grade construction aggregate used in Portland cement concrete (an indispensable building material that is costly to transport).

The Yuba City-Marysville area, due to its long history of gold dredging with the resulting tailings, has vast quantities of low-cost, high-quality aggregate materials locally available. At the present rate of urbanization, the total available resource is more than ample for future development. Metropolitan areas to the south are not so fortunate. In rapidly urbanizing areas, such as the San Francisco Bay area and Sacramento, the total available resource is quickly being depleted or precluded from mining by other urban land uses. The Yuba City-Marysville area is a primary alternative aggregate source for these neighbors with limited local aggregate supplies.

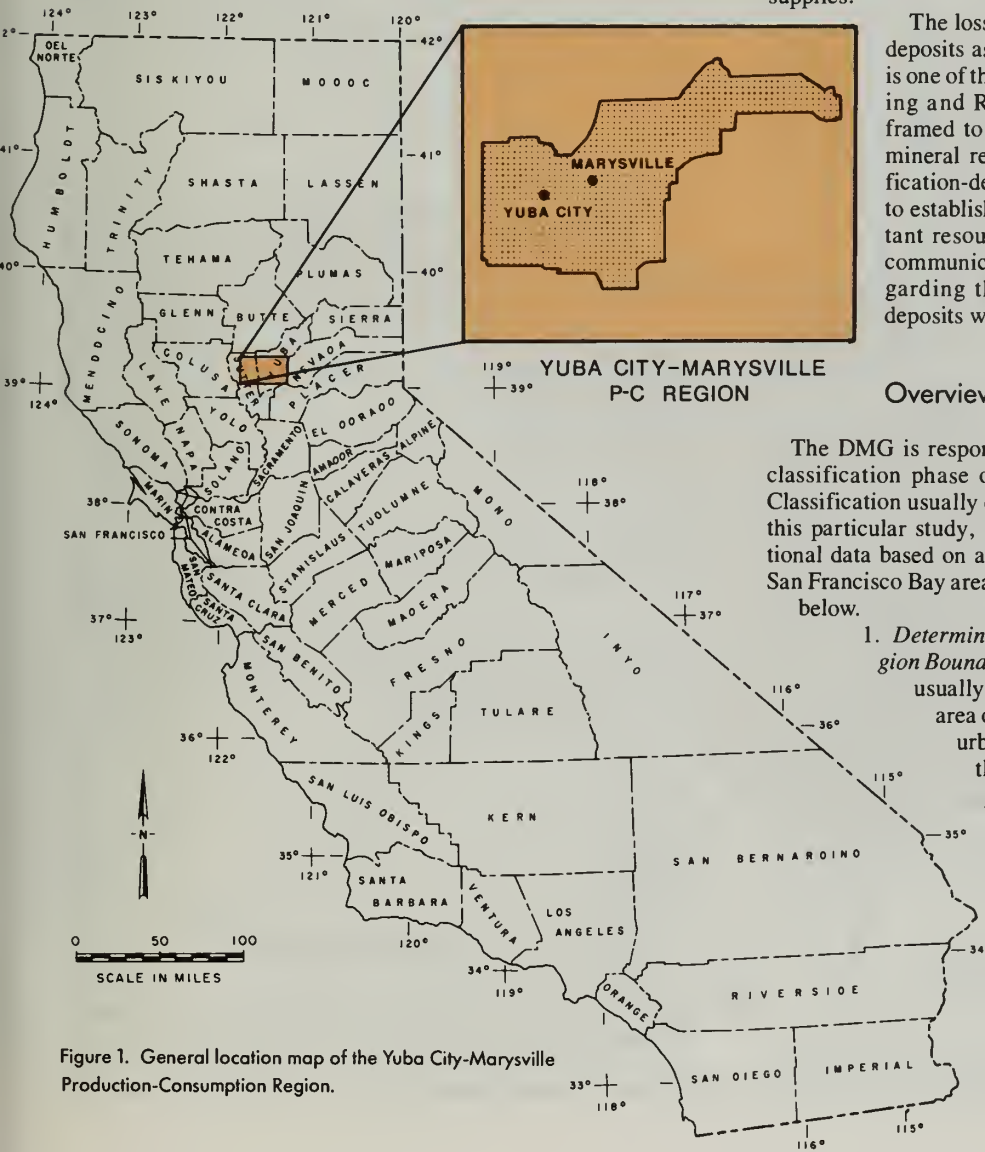

Figure 1. General location map of the Yuba City-Marysville Production-Consumption Region.

The loss of access to regionally significant mineral deposits as a result of land uses that preclude mining is one of the problems that the California Surface Mining and Reclamation Act of 1975 (SMARA) was framed to address. SMARA mandates a two-phased mineral resource conservation process called classification-designation. The objective of this process is to establish an awareness of the availability of important resources to urban population centers through communication with the appropriate lead agencies regarding the location and significance of mineral deposits within their region.

Overview of Classification

The DMG is responsible under SMARA for carrying out the classification phase of the classification-designation process. Classification usually entails six distinct but interrelated steps. In this particular study, a seventh step is included to provide additional data based on a hypothetical depletion of Sacramento and San Francisco Bay area resources. These seven steps are described below.

1. *Determination of Production-Consumption (P-C) Region Boundaries.* The boundaries of the P-C region are usually drawn along the limits of the marketing area of active aggregate operations supplying the urban center under study. However, because of the size and quality of the Yuba City-Marysville deposit and the shortages of aggregate in the neighboring P-C regions, about 55 percent of the aggregate produced from the deposit is marketed outside the P-C region. Included within the Yuba City-Marysville P-C Region boundaries are all areas that have been identified as urbanized or urbanizing by the State Office of Planning and Research (OPR) and the area of active aggregate operations supplying the urban center of Yuba City-Marysville.

2. *Establishment of Mineral Resource Zones (MRZ).* All lands within the Yuba City-Marysville P-C Region are assigned Mineral Resource Zone classifications (MRZ-1, MRZ-2, MRZ-3, or MRZ-4) based upon a geologic appraisal of the PCC-grade aggregate resource potential of the land. This appraisal includes study of pertinent geologic reports and maps, field investigation and sampling at outcrops and at active and inactive pits and quarries, and analysis of water-well logs and drill records. In addition, all active mines within the P-C region that meet the criteria for significance have been classified MRZ-2, regardless of the mineral commodity they produce. These mines have been shown on plates accompanying this report with the symbol MRZ-2 followed by an identifier specifying the commodity produced [MRZ-2 (Base), MRZ-2 (riprap), or MRZ-2 (Gold)].

3. *Identification of Available Aggregate Deposits as Sectors.* Lands containing significant deposits of PCC-grade sand and gravel (areas classified MRZ-2 in step 2) are evaluated to determine whether or not current uses of these lands preclude possible future mining. Areas currently permitted for mining and areas found to have land uses compatible with possible future mining are considered available for mining and are identified as resource sectors. These sectors are delineated and described in detail. Criteria for sectorization of MRZ-2 areas, established by the Board, are given in Appendix A.

4. *Calculation of Resource Tonnages within Sectors.* Investigation and analysis of on-site conditions, measurement of the areal extent of deposits, drill-hole information, waste-material percentages, and deposit densities are used to calculate total tonnages of PCC-grade aggregate *reserves* (deposits in land owned or leased by an aggregate producer and permitted for mining by local government at the end of 1985) and *resources* (all deposits of PCC quality including the reserves) within each sector. Calculations reflect conditions of the deposits at the end of 1985; resource depletion by mining since that time has not been considered.

5. *Forecast of 50-Year Needs and the Life Expectancy of Current Reserves.* The total tonnage of aggregate needed to satisfy demand in the Yuba City-Marysville P-C Region over the next 50 years is estimated based on a comparison of the projected population over the period with the average annual per-capita rate of aggregate consumption from 1964-1984. Even though all identified reserves are of PCC quality, other aggregate commodities are routinely produced

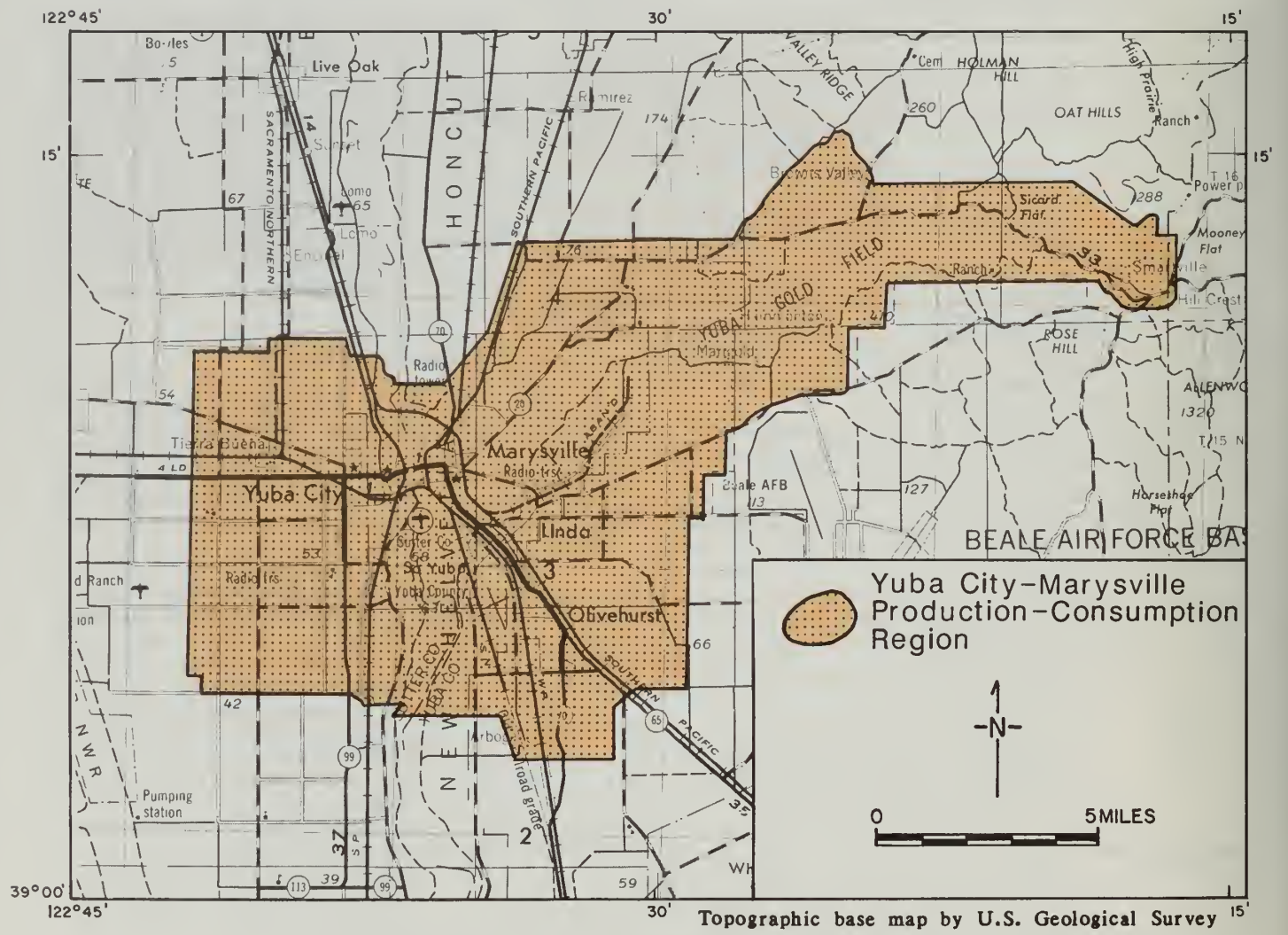

Figure 2. The Yubo City-Marysville Production-Consumption Region boundaries.

and marketed from them. The projected life expectancy of the reserves is based on the assumption that this practice will continue. Results of this forecast are used to determine the life expectancy of the P-C region's current reserves.

6. *Identification of Alternative Resources*. Alternative sources of aggregate to meet the forecast 50-year demand are identified and briefly considered.

7. *Transportation Analysis of Supplying Aggregate to San Francisco and Sacramento*. The major consideration in supplying neighboring areas with aggregate material is the mode of transportation and the related economics. Three different modes of transportation are discussed and the related economics are briefly considered.

Brief Overview of Designation

The present report is concerned with the classification phase of the two-step process mandated by SMARA. The designation phase follows receipt and approval of this classification report by the State Mining and Geology Board. Based upon the sector descriptions provided by the DMG, and input from local lead agencies and the public, the Board may adopt regulations which "designate" certain mineral resource deposits as being regionally significant to satisfy future needs. Such designation, if made, would be included as part of the state policy.

Overview of Aggregate Uses

Sand, gravel, and crushed stone are "construction materials." These commodities, collectively referred to as aggregate, provide bulk and strength to Portland cement concrete, asphaltic concrete, and plaster or stucco. Aggregate is also used as road base, subbase, railroad ballast and fill. Aggregate normally provides from 80 to 100 percent of the material volume in the above uses.

Aggregate material is essential to the needs of a modern society. It is a resource of great importance to the economy of any metropolitan area. Enormous tonnages of high quality PCC-grade aggregate are used in concrete highways, dams, canals, airport runways, bridge abutments, foundations, buildings and general construction.

During 1984, about 0.86 million tons of aggregate, worth about $2.6 million, were mined from the Yuba River deposits. Approximately 29 percent of the aggregate produced here from 1964 to 1984 was used as Portland cement concrete (PCC) aggregate (U.S. Bureau of Mines statistics).

In this aggregate resource classification study, special emphasis is given to aggregate that meets the specifications used in making Portland cement concrete (PCC). The material specifications for PCC-grade aggregate are more restrictive than the specifications that aggregate for other applications must meet. The restrictiveness of these specifications makes deposits acceptable for use as PCC aggregate the scarcest and most valuable of aggregate resources. Because of the high specifications, the aggregate produced from such deposits can be, and is commonly, used for other purposes than concrete aggregate. Because of its versatility, its value, its importance in construction and its relative scarcity, PCC-grade aggregate deposits are of the most concern when planning for the future availability of aggregate commodities.

Rarely, even from the highest-grade deposits, is in-place aggregate raw material physically or chemically suited for every type of aggregate use. Every potential deposit must be tested to determine how much of its material can meet specifications for a particular use, and what processing is required. Specifications for various uses of aggregate material have been established by several agencies, such as the U.S. Bureau of Reclamation, the U.S. Army Corps of Engineers, and the California Department of Transportation (Caltrans), to ensure that aggregate is satisfactory for specific uses. These agencies, and other major consumers of concrete, test aggregate for acceptance by standard test procedures outlined by such organizations as the American Society for Testing Materials and the American Association of State Highway Officials.

Most aggregate specifications have been established to ensure the manufacture of strong, durable structures capable of withstanding the physical and chemical effects of weathering and use. For example, specifications for Portland cement concrete and concrete products prohibit or limit the use of rock materials containing mineral substances such as gypsum, pyrite, zeolites, opal, chalcedony, chert, siliceous shale, volcanic glass, and some high-silica volcanic rocks. Gypsum shortens the setting time of Portland cement, pyrite dissociates to yield sulfuric acid and iron oxide stain, and other substances contain silica in a form that reacts with alkali substances in the cement, resulting in cracks and "pop-outs."

Specifications also call for precise particle-size distributions in the various uses of aggregate. Aggregate is commonly classified into two general sizes, coarse aggregate and fine aggregate. Coarse aggregate is rock retained on a 3/8" or a #4 U.S. sieve. Fine aggregate passes a 3/8" sieve and is retained on a #200 U.S. sieve (a sieve with 200 weaves per inch). For some uses, such as asphalt paving, particle shape is specified. The Caltrans Standard Specifications (1981) require that at least 25 percent by weight of coarse aggregate (1/4 inch to 3/4 inch diameter) used as Class 2 aggregate base material shall be crushed particles. Furthermore, aggregate material used with bituminous binder to form sealing coats on road surfaces shall consist of at least 90 percent by weight of crushed particles. Crushed stone is preferable to natural gravel in asphaltic concrete because asphalt adheres better to broken surfaces than to rounded surfaces, and the interlocking of angular particles strengthens the asphaltic concrete and road base.

The preferred use of one aggregate material over another in construction practices depends not only on specification standards, but also on economic considerations. Alluvial gravel is preferred to crushed stone for Portland cement concrete aggregate because the rounded particles of alluvial sand and gravel result in a mix that is easier to work than a mix composed of angular fragments. The workability of a mix consisting of Portland cement with crushed stone aggregate is improved by adding more sand and water. More cement must then be added to the mix to maintain concrete durability standards. At the present time, the additional cement amounts to about a quarter of a 94 pound sack per cubic yard of concrete at an additional cost of over $1.00 per yard of mix. Although more care is required in pouring and placing a mix containing crushed stone, Portland cement concrete made with this aggregate is as satisfactory as that made with sand and gravel of comparable rock quality.

In the Yuba City-Marysville area, PCC aggregate sells in bulk for about $4.00 per ton at the plant site (in late 1985). However, this selling price reflects only part of the costs to the consumer. Transport costs are a significant part of the final delivery price. In areas that lack nearby aggregate sources, the delivery charges alone may be greater than the sale price of the material at the plant site.

Background and Purpose

Urban expansion has been a major contributing factor to the loss of significant mineral resources in past years. In response to the problem of conflicting land use and the essential need for

mineral products, the California State Legislature enacted the Surface Mining and Reclamation Act of 1975 (SMARA). SMARA requires the State Geologist to classify*, according to the presence or absence of significant mineral deposits, certain areas of the state which are subject to urban expansion or other irreversible land uses incompatible with mining. Urbanizing areas are identified by the State Office of Planning and Research (OPR). The boundaries of the areas are modified to reflect current land use through consultation with local lead agencies and selected on-site field inspection.

The State Mining and Geology Board, upon receipt of the classification information from the State Geologist, transmits the classification report to the appropriate lead agencies and makes it available to other interested parties. Upon receipt of the classification report, each lead agency must within 12 months thereof, develop and adopt mineral resource management policies to be incorporated in its general plan. These policies will:

1. Recognize the mineral classification information, including the classification maps, transmitted by the Board.
2. Emphasize the conservation and development of identified significant mineral deposits.

After receipt of mineral classification information from the State Geologist, the State Mining and Geology Board may designate specific geographic areas that contain mineral deposits of regional significance. Procedures for designation** of lands containing significant mineral deposits are specified in Section II.2 of the State Mining and Geology Board's "Guidelines for Classification and Designation of Mineral Lands," which is included as Part II of California Division of Mines and Geology Special Publication 51, "California Surface Mining and Reclamation Policies and Procedures" (1983). This publication is available from the Division of Mines and Geology free of charge.

*Classification is the process of identification of lands containing significant mineral deposits based solely on geologic factors, and without regard for present land use or land ownership.

**Designation is the formal recognition by the State Mining and Geology Board, after consultation with lead agencies and other interested parties, of areas containing mineral deposits of regional or statewide significance that should be considered for protection from land uses incompatible with mineral extraction. These deposits are deemed to be of prime importance in meeting the future needs of the region or the state.

The objective of the classification and designation process is to ensure, through appropriate lead agency policies and procedures, that raw material is available when needed and does not become inaccessible as a result of a lack of information during land-use decision-making actions.

The "Guidelines for Classification and Designation of Mineral Lands" were adopted by the State Mining and Geology Board on June 30, 1978. The purpose of the guidelines is to implement SMARA by providing direction to the State Geologist in carrying out mineral resource classification, and to establish procedures by which the Board may designate mineral-bearing lands of statewide or regional significance. Section I.1.a of the guidelines requires that the State Geologist classify specified areas into *Mineral Resource Zones* (MRZ) or *Scientific Resource Zones* (SZ) as defined in Section I.2 of the guidelines. Although California has a wide range of mineral commodities within its borders, the State Mining and Geology Board recognizes that construction materials (sand, gravel, and crushed stone) are produced regionally, are used in every urban area of the state, and require special classification data. Section I.3 of the guidelines requires that classification reports that pertain to deposits of construction materials include the following information: (1) the location and estimated total quantity of construction material that is geologically available for mining; (2) limits of the market (production-consumption) region which the potential resource would serve; and (3) an estimate of the total quantity of material that will be needed to supply the requirements of the consumption region for the next 50 years. This information will assist the State Mining and Geology Board in determining the statewide or regional significance of these types of deposits.

The Mineral Land Classification of the Yuba City-Marysville Production-Consumption Region was initiated in 1984 by the State Geologist. Portland cement concrete-grade aggregate resources of the area were selected for initial classification. The Yuba City-Marysville area was selected because it was known to contain large volumes of PCC-grade aggregate in the dredge tailings of the historic Yuba River dredge fields. This aggregate will very likely become increasingly important as resources in the large market regions of Sacramento and the South San Francisco Bay area are depleted or made inaccessible to mining.

DETERMINATION OF THE YUBA CITY-MARYSVILLE P-C REGION

The initial focus of this classification study was on the Yuba City-Marysville area. The work began by defining the production-consumption (P-C) region for this small urban area. Subsequently, it was learned that the aggregate needs of the area were easily being met by seven active PCC aggregate pits (Figure 3), and that approximately 55 percent of their production was being sold to neighboring areas. The Sacramento area was found to be one of the major consumers. Sacramento was not directly considered to be within the P-C region because at least 90 percent of its aggregate needs are still served by local deposits (DMG Special Report 156). However, in subsequent studies of the Sacramento P-C Region, the Yuba City-Marysville area may be included as part of a greater Sacramento P-C Region.

The next task in this study was the definition of the marketing areas of the Yuba River production district through a review of past marketing practices. It was found that for the years 1984 and 1985, 55% of the aggregate produced in the district was delivered to areas outside of the Yuba City-Marysville P-C Region (Figure 4). Most of the exported aggregate went to the Sacramento area (about 42% of the total production of the Yuba River production district). About 10% of the district production went to the Foothills area, and small amounts were delivered to the areas north and west of the Yuba City-Marysville P-C Region. Transportation costs are critical in determining the market region of an aggregate deposit and are therefore addressed in detail.

Transportation Rates

Because aggregate is a low-value, high bulk-weight commodity, a major part of its cost to the consumer is for transportation. The increased aggregate costs to the consumer due to transport charges can be demonstrated using a delivery site in downtown Sacramento as an example. A ton of PCC aggregate mined and processed at the Yuba River dredge fields for a price of $4.00 per ton at the plant and delivered to Sacramento by truck (a distance of 45 miles) would cost the consumer a minimum of $8.79 per ton including $4.79 for transport charges (Table 1). Additional labor and fuel surcharges could significantly increase the costs to the consumer. The final delivery price in Sacramento would be, at least, nearly

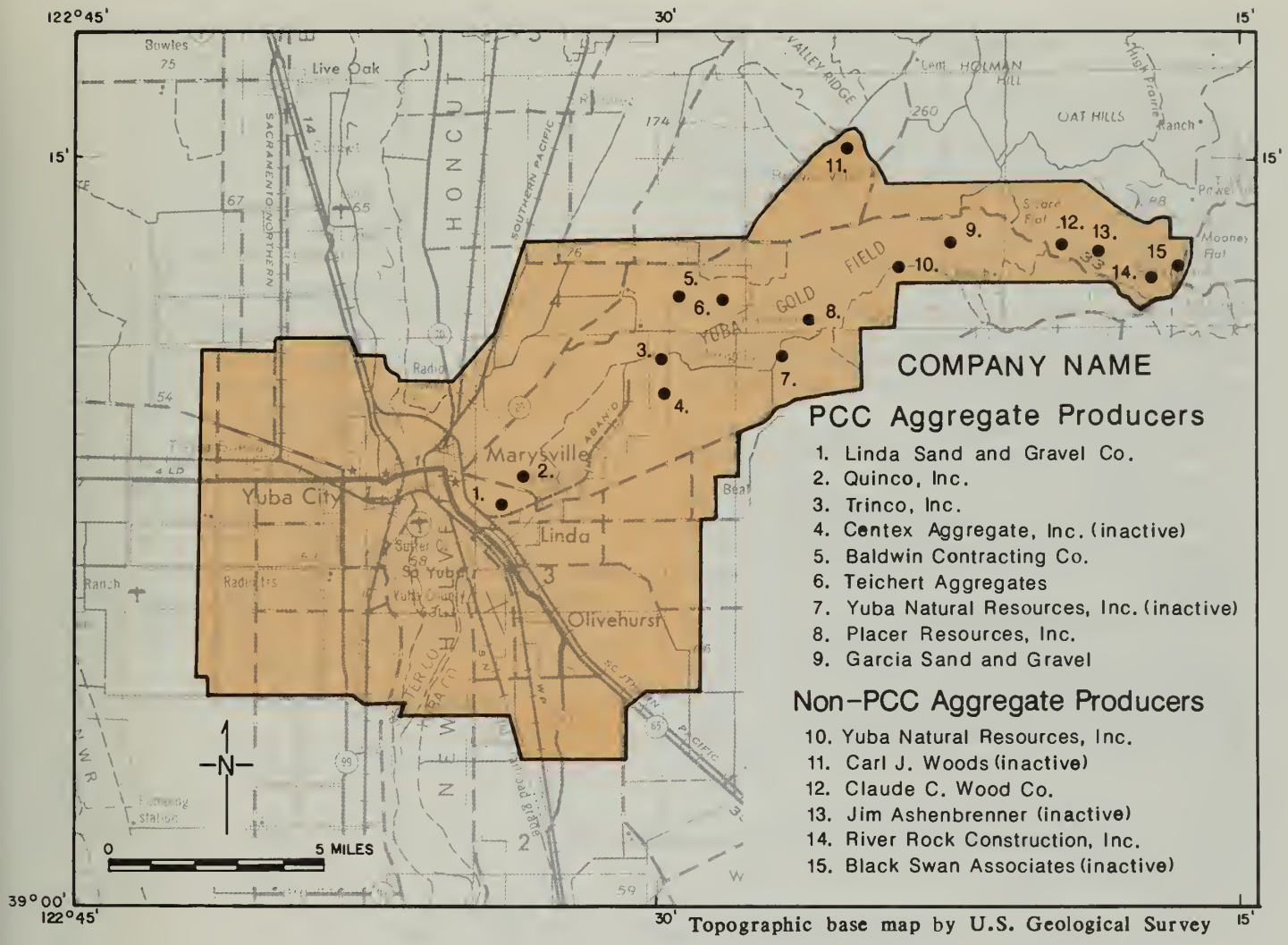

Figure 3. Locations of PCC aggregate producers and other mineral producers in the Yuba City-Marysville Production-Consumption Region.

double the selling price at the plant in the Yuba River area. As a consequence of transportation costs, an important factor in determining the marketing region of an aggregate plant is the distance its product can be hauled and still be sold at a competitive price.

All aggregate marketed in the Yuba City-Marysville P-C Region is transported by truck. Minimum rates for independent aggregate truckers are set by the California Public Utilities Commission and are called "Minimum Rate Tariffs" (MRT). These rates vary with geographic area, the number of truck axles, and whether the trucking is done on weekdays, Saturdays, Sundays, or holidays. The Minimum Rate Tariff for the study area is MRT 7-A, which lists the minimum hourly rates and minimum distance rates that have been established for northern California.

For aggregate truck transport in the study area, the current minimum hourly rates established by MRT 7-A range from $38.00 per hour for a two-axle truck to $47.95 per hour for a five-axle truck. MRT 7-A also specifies minimum distance rates for aggregate hauling. In the Yuba City-Marysville area, the minimum rate for a distance of 45 miles is $4.79 per ton hauled. The minimum hourly rate or the minimum distance rate, whichever is larger, may be charged to the consumer. Truckers in the Yuba City-Marysville area commonly charge a larger amount than specified in MRT 7-A, providing the charge is mutually agreed upon by the trucker and the shipper (California Public Utilities Commission, 1985).

TABLE 1. Minimum rates for transport of aggregate in the Yuba City-Marysville area. From California Public Utilities Commission, 1985, Minimum Rate Tariff 7-A.*

DISTANCE RATE** (for selected increments)		HOURLY RATES***	
Miles	Rates ($/ton)	# of Axles per Unit of Equipment	Rate ($)
10	1.51	2	38.00
20	2.50	3	43.00
30	3.43	4	44.50
40	4.34	5+	47.95
45	4.79		
50	5.43		
60	6.11		
75	7.38		

*The minimum hourly rate or the minimum distance rate, whichever is larger, may be charged to the consumer.

**Includes November, 1985 increase in surcharge; rates are higher for work done on holidays or weekends and if equipment other than a "tractor with bottom dump doubles in train" are required at the destination.

***Current as of November, 1985: rates are higher for work done on holidays and weekends.

P-C Region Boundaries

P-C region boundaries were drawn so that they encompass all major urbanizing areas (with a population of 10,000 or more), and associated areas projected for future urbanization within the marketing areas of the Yuba River production district. Lead agencies with jurisdiction within the Yuba City-Marysville P-C Region are listed on Table 2.

Maps supplied by the State Office of Planning and Research (OPR) served to identify urbanized and urbanizing areas within the Yuba City-Marysville area. These maps are part of a series issued by the Office of Planning and Research in July 1975 entitled "Urban Expansion Map of California." The generalized maps were published at a scale of 1:500,000 (one inch equals approximately 8 miles) and show "Existing Urban — 1970" and "Projected Urban — 1990" areas.

The "existing urban" areas shown on the OPR maps represent the *urbanized* areas used as the basis for the land classification maps developed during the present study; the "projected urban" areas are the *urbanizing* areas. The local lead agencies in the Yuba City-Marysville area use the OPR map for their urban planning and have not projected future urbanization beyond the OPR urbanizing areas. The urban and urbanizing area boundary is shown on Figure 5.

The P-C region boundaries were drawn to include these "urban" or "urbanizing" areas as well as all areas containing active aggregate mines and significant aggregate deposits that lie outside of the urbanizing boundaries that are within an economic haul distance of the Yuba City-Marysville consumption area. These deposits were included in the P-C region because they contain over 98 percent of the aggregate resources for the Yuba City-Marysville area.

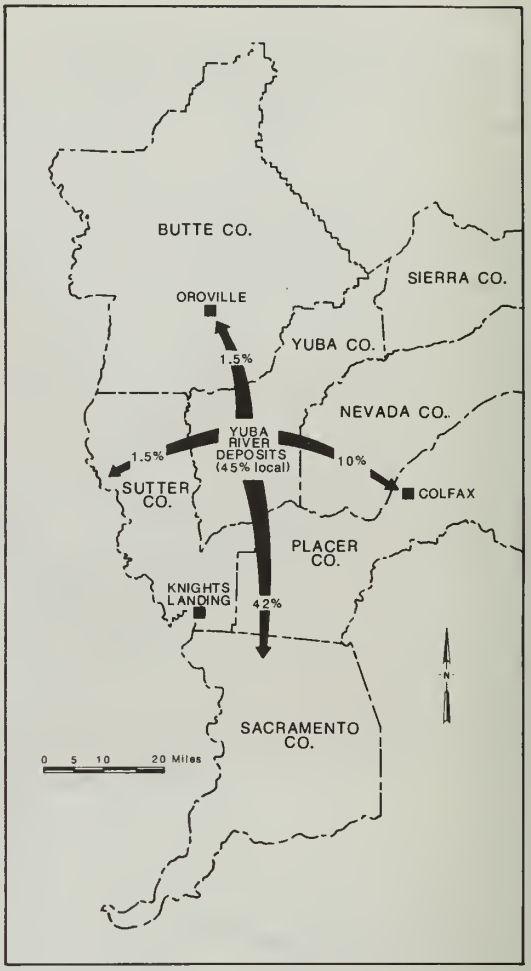

Figure 4: Yuba River aggregate marketing distribution pattern for the years 1984 - 1985.

ESTABLISHMENT OF MINERAL RESOURCE ZONES

The DMG has classified land in the Yuba City-Marysville P-C Region according to the presence or absence of significant PCC-grade aggregate deposits. The land classification is presented in the form of Mineral Resource Zones (MRZ). Directions for the identification of Mineral Resource Zones are set forth in DMG's Special Publication 51 in the section entitled "Guidelines for Classification and Designation of Mineral Lands" (California Division of Mines and Geology, 1983).

The guidelines for establishing the Mineral Resource Zones are as follows:

MRZ-1 Areas where adequate information indicates that no significant mineral deposits are present, or where it is judged that little likelihood exists for their presence. This zone shall be applied where well-developed lines of reasoning, based upon economic-geologic principles and adequate data, demonstrate that the likelihood for occurrence of significant mineral deposits is nil or slight.

MRZ-2 Areas where adequate information indicates that significant mineral deposits are present, or where it is judged that a high likelihood for their presence exists. This zone shall be applied to known mineral deposits or where well-developed lines of reasoning, based upon economic-geologic principles and adequate data, demonstrate that the likelihood for occurrence of significant mineral deposits is high.

MRZ-3 Areas containing mineral deposits, the significance of which cannot be evaluated from available data.

MRZ-4 Areas where available information is inadequate for assignment to any other mineral resource zone.

Mineral Resource Zones in the Yuba City-Marysville P-C Region are presented on 8 U.S. Geological Survey topographic maps at a scale of 1:48,000 that accompany this report (Plates 1-8). Figure 6 shows the quadrangle maps that cover the Yuba City-Marysville area.

Mineral resource zones within the Yuba City-Marysville P-C Region were established on the basis of an aggregate appraisal that included the following tasks for assessing the quantity, quality, and extent of the aggregate deposits:

1. Examination and compilation of relevant geologic maps, aerial photos, geologic literature, aggregate industry data (some of which is proprietary) and aggregate engineering test data. The geologic maps used in the classification of the Yuba City-Marysville P-C Region include:

   Helley, E.J. and Harwood, D.S., 1985, Geologic Map of the Late Cenozoic Deposits of the Sacramento Valley and Northern Sierran Foothills:

Department of the Interior, United States Geological Survey MF 1790,

Burnett, J.L. and Jennings, C.W., Compilers, 1962, Geologic Map of California, Chico Sheet: California Division of Mines and Geology, scale 1:250,000, and

U.S. Department of the Army, Corps of Engineers, 1977, Fault evaluation study, Marysville Lake project, Yuba River, California, p. 25.

Figure 7 shows the generalized geology of the area and Figure 8 shows a generalized stratigraphic section of the Yuba River production district.

2. Interviews with aggregate operators, company geologists, and consultants.
3. Compilation and analysis of subsurface well-log data and drilling records.
4. Field investigation of active and depleted aggregate quarries.
5. Field checking of the compiled geologic map and inspection of untested surficial aggregate deposits.

In this study, an understanding of the origins of the alluvial deposits was particularly helpful in the delineation of MRZs, because most alluvial deposits in the Yuba City-Marysville area are similar to each other in lithology throughout their extent. In some instances, however, lithologic changes within a formation made it necessary to assign more than one MRZ category to a single formation. An example of this is provided in the classification of the Riverbank Formation which does not contain consistently high-grade aggregate throughout its extent. In some areas, the presence of friable rock, clay lenses, and excessive amounts of silica-iron cemented hardpan results in rock that does not meet PCC-grade aggregate specifications. Because of major lithologic changes within the formation, different parts of the Riverbank Formation have been classified MRZ-1, MRZ-2, or MRZ-3.

TABLE 2. Lead agencies (counties and incorporated city governments) located within the Yuba City-Marysville P-C Region.

AGENCIES	
COUNTIES	CITIES
Nevada* +	Marysville
Sutter	Yuba City
Yuba* + †	

* Agencies with active aggregate operations within their jurisdictional boundaries.
\+ Agencies that have land classified MRZ-2 within their jurisdiction.
† Lead agencies containing sectors.

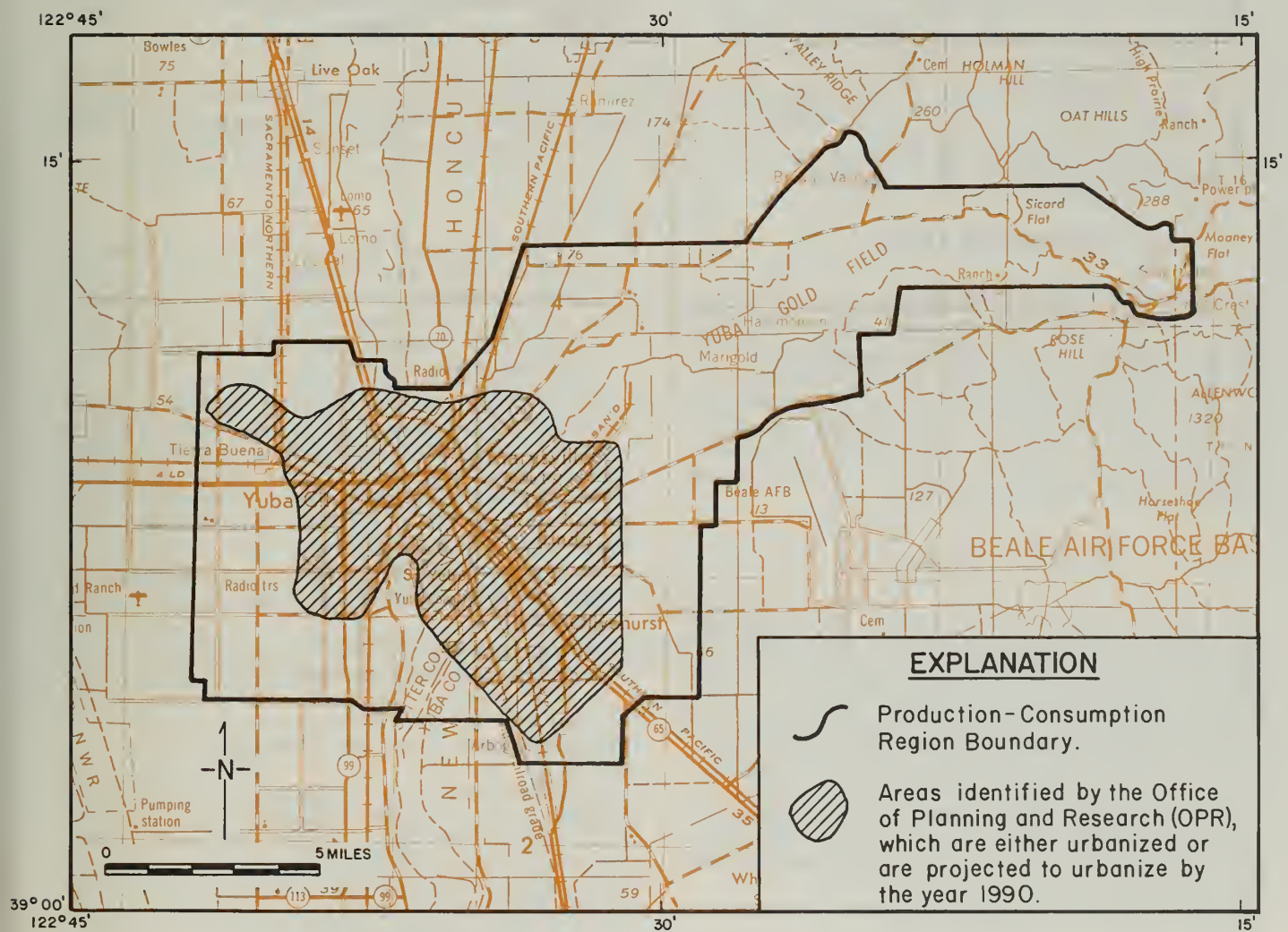

Figure 5. Urbanized and urbanizing areas of the Yuba City-Marysville Production-Consumption Region.

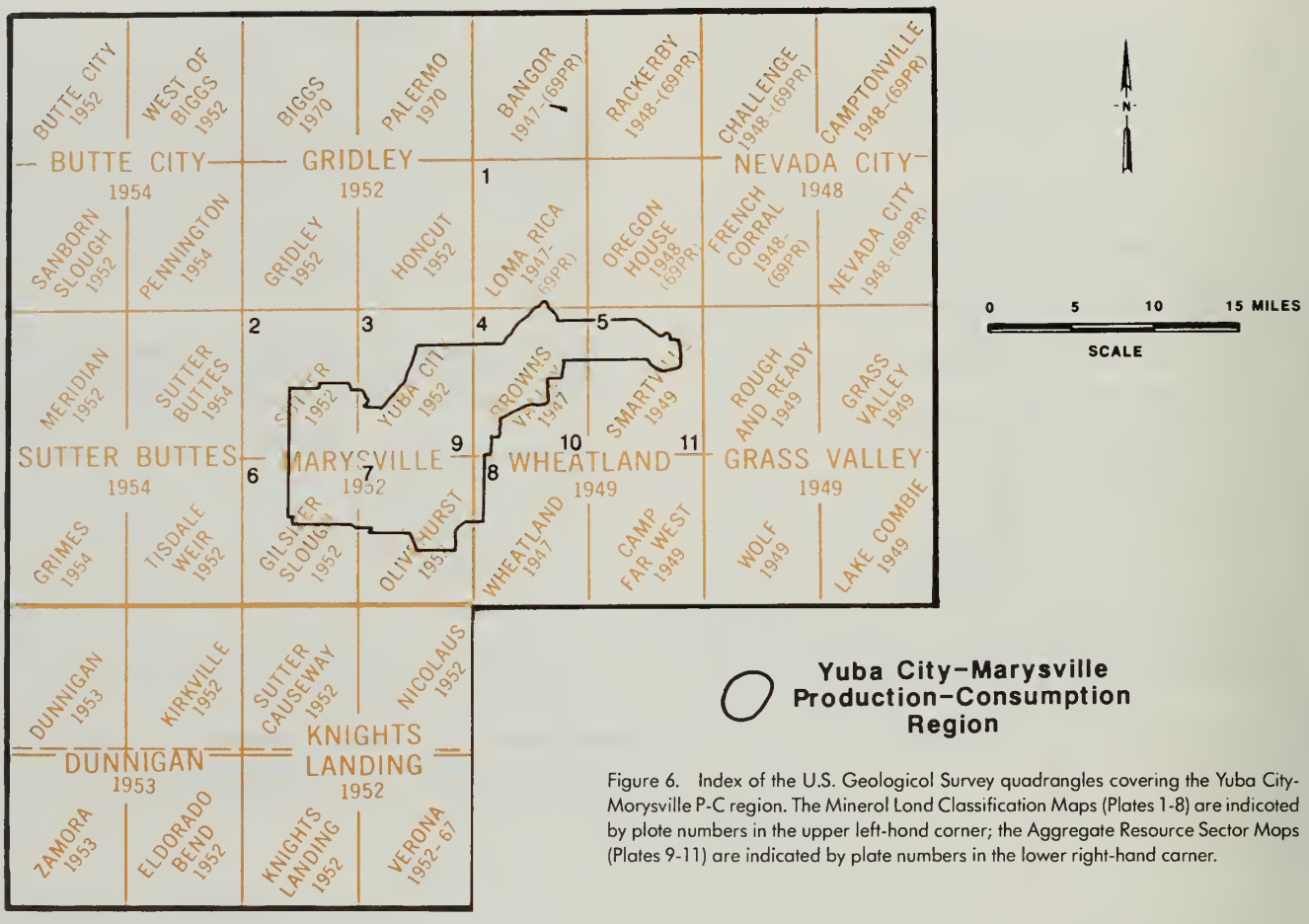

Figure 6. Index of the U.S. Geologicol Survey quadrangles covering the Yuba City-Morysville P-C region. The Minerol Lond Classification Maps (Plates 1-8) are indicoted by plote numbers in the upper left-hond corner; the Aggregate Resource Sector Mops (Plates 9-11) are indicated by plate numbers in the lower right-hand corner.

Areas Classified MRZ-1

Areas classified MRZ-1 were judged on the basis of available data to have little likelihood of containing significant deposits of PCC-grade aggregate. Deposits that have excessive amounts of clay, silt, organic matter, absorptive rock, alkali-reactive rock, platy rock, or soft rock are unsuitable use as PCC aggregate and deposits are classified MRZ-1. Most areas in the Yuba City-Marysville P-C Region that are classified MRZ-1 are underlain by alluvial material judged to contain too much clay, silt, and decomposed rock for use as PCC aggregate.

Areas Classified MRZ-2

One large area within the Yuba City-Marysville P-C Region is classified MRZ-2 for PCC aggregate (Figure 9). Data confirm that most of the dredge tailings and a large area downstream of the dredge tailings in the Yuba River area east of Marysville contain PCC-grade aggregate and exceed threshold value. Three areas within the Yuba City-Marysville P-C Region are classified MRZ-2 for commodities other than PCC-grade aggregate. A deposit in the Timbuctoo area is classified MRZ-2 for base and subbase, a deposit of metavolcanic rocks is classified MRZ-2 for rip-rap, and the dredge field in the Yuba River is also classified MRZ-2 for gold. A description of these areas is given in the section on classification of non-PCC-grade aggregate commodities.

SMARA guidelines set forth two requirements to be used to determine if land should be classified MRZ-2:

1. The deposit must be composed of material that is suitable as a marketable commodity.
2. The deposit must meet threshold value. The projected value (gross selling price) of the deposit, based on the value of the first marketable product, must be at least $8,450,000 (5 million 1978 dollars).

Areas classified MRZ-2 for PCC-grade aggregate contain aggregate resources that either are proven or have a high probability to be PCC-grade aggregate. Much of the aggregate in the MRZ-2 areas has not been identified as PCC-grade aggregate through formal engineering tests. Aggregate deposits in untested, unproven areas identified as MRZ-2 are believed to contain PCC-grade aggregate for the following reasons:

- The aggregate in unproven areas is similar in age, lithology, and mode of deposition to that of the proven PCC-grade aggregate.
- The unproven deposit is a lateral extension of the alluvial formation from which PCC-grade aggregate has been produced.

GEOLOGIC SETTING OF THE MRZ-2 DEPOSITS

Thc Yuba City-Marysville P-C Region is within and adjacent to the Sierra Nevada foothills. Metamorphic volcanic rocks of Jurassic age underlie the adjacent foothills to the east of the study area. Recent deposits comprised of unconsolidated sandy and clayey sediments can be found in the western portion of the study area. Remnants of old deposits of lagoon, alluvial, and mudflow origin can be seen adjacent to the foothills; however, most of these

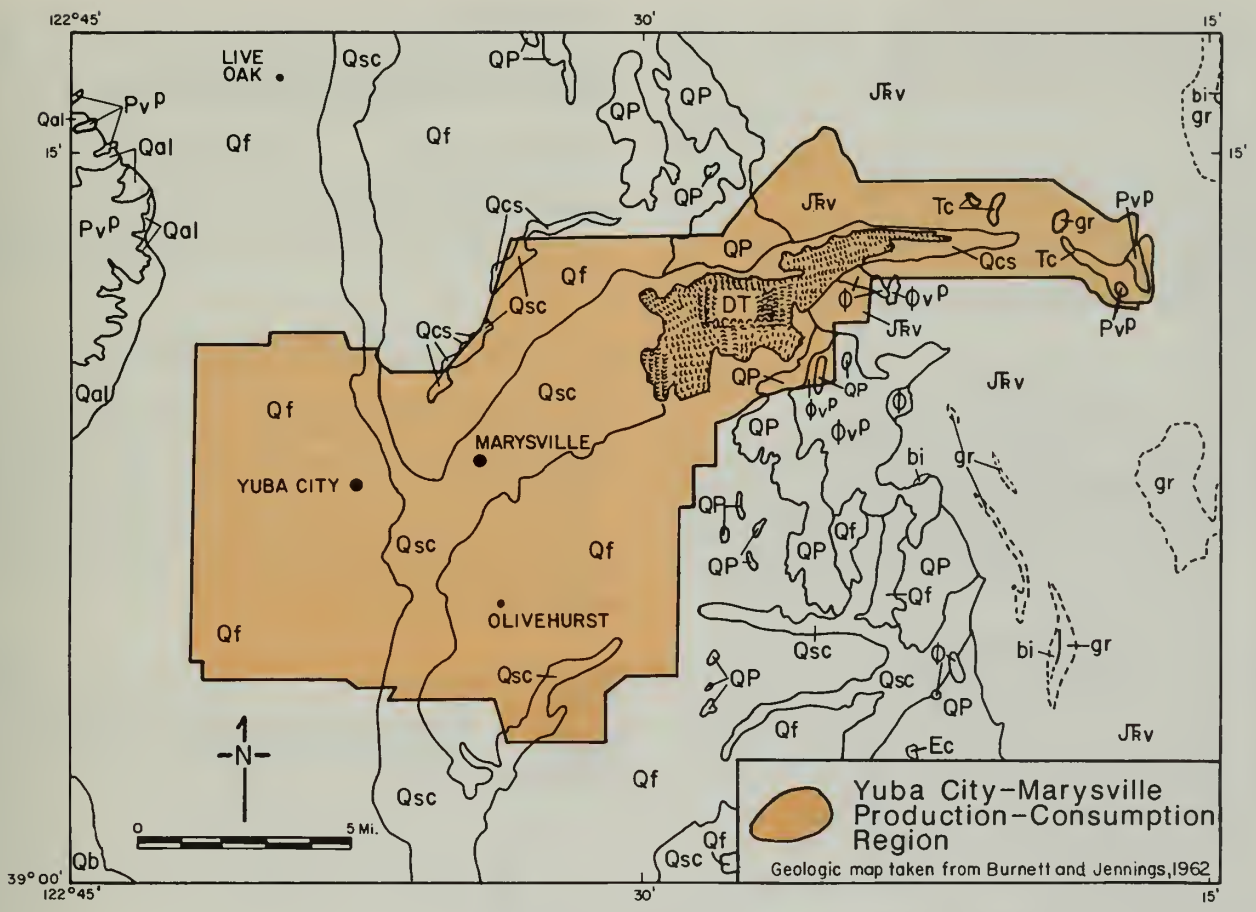

Figure 7. Generalized geologic map of the Yuba City-Marysville area.

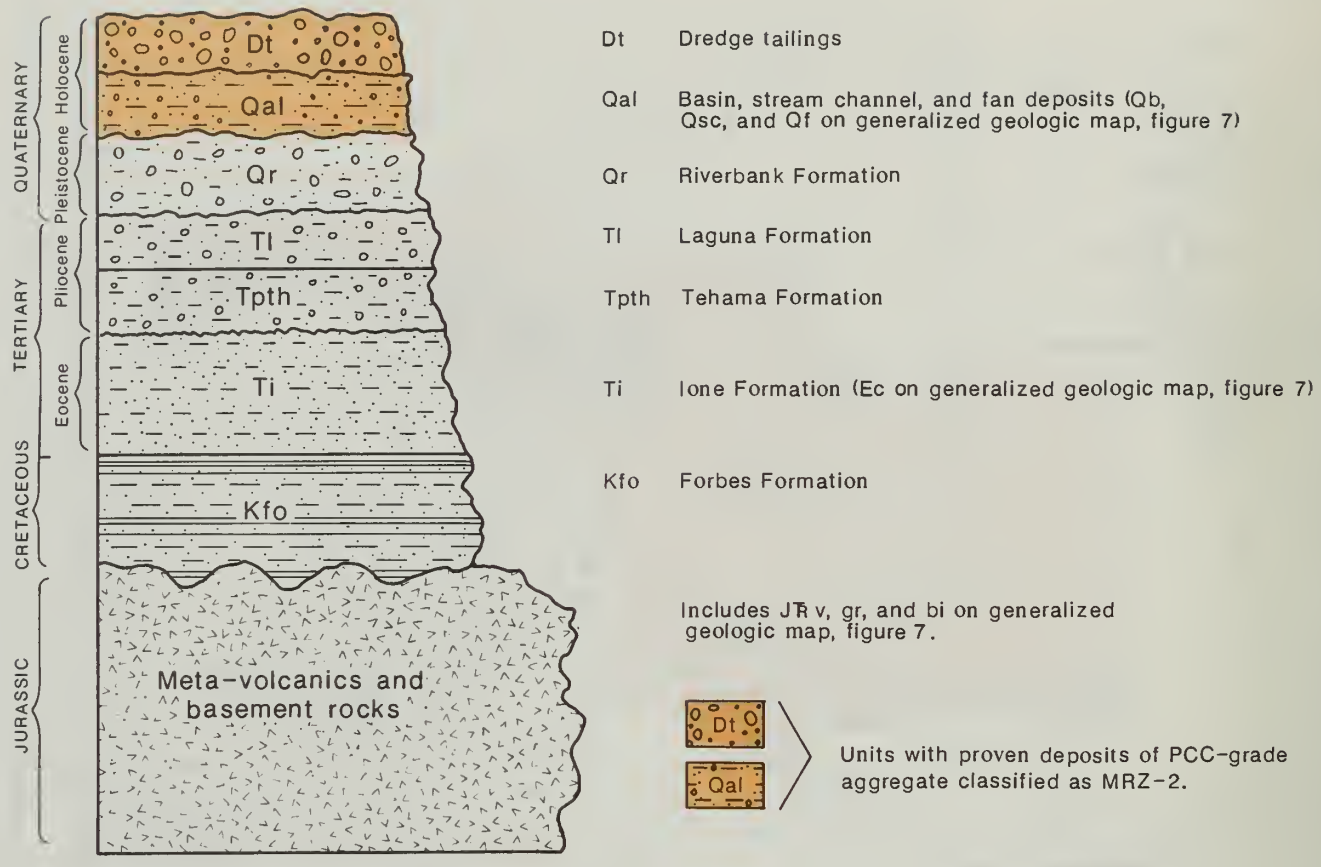

Figure 8. Generalized stratigraphic section of the Yuba River resource area.

deposits have been eroded or buried under the younger valley sediments. Steep rock walls and long narrow valleys have been formed by the Yuba River and can be seen upstream of Parks Bar.

The remnants of the early Tertiary Yuba River can be traced from Grass Valley through Timbuctoo and down to where the present Yuba River meets the Feather River at Marysville. The early Yuba River flowed on a gently sloping surface across what is now the Sierra Nevada Mountains, long before their uplift. The ancient channel now has a gradient averaging about 100 feet/mile due to the lifting of the Sierra block, compared to the current gradient for the Yuba River of close to 10 feet/mile (U.S. Department of the Army, 1977, Fault evaluation study).

As a result of this tilting and subsequent erosion, old gravel deposits lie on the top of hills at Grass Valley, and beneath the lower hills further west near Timbuctoo bend. The current river channel and the early Tertiary river channel intersect at Long Bar which is located at the eastern edge of the Yuba River dredge tailings. From this point westward the old alluvium fills a buried valley and is overlain by younger alluvium near Hammonton (U.S. Department of the Army, Corps of Engineers, 1974).

YUBA RIVER RESOURCE AREA

The Yuba River resource area, which is classified MRZ-2, extends along the Yuba River from upstream of the town of Smartsville, downstream (southwestward) to the city of Marysville. There are nine PCC aggregate companies that are permitted to mine in this area, of which two are inactive (Figure 3).

The Yuba River MRZ-2 area consists of four types of deposits: 1) natural stream channel and floodplain alluvium, 2) hydraulic wash deposits from upstream monitor workings, 3) dredge tailings which are reworked natural alluvium and hydraulic wash deposits, and 4) recent stream channel alluvium in the present channel of the Yuba River.

The natural alluvium was deposited from Tertiary to recent times when the Yuba River carried large volumes of sand, gravel, and silt into the Central Valley. The abrupt decrease in gradient as the river entered the flat valley caused a decrease in stream transport energy which resulted in sediment deposition, and the creation of the floodplain. This is a normal fluvial transport process and occurs mainly during flood stages.

The hydraulic wash deposits were emplaced during the late 1800's, primarily from 1852, when hydraulic mining started in upstream drainage areas of the Yuba River, until 1893 when the Caminetti Act was passed creating the California Debris Commission. During this time Aubury estimated "... that aside from the natural sedimentation due to erosion, that nearly half a billion cubic yards of hydraulic tailings have been carried down yearly by the flood waters and deposited in the river valley" (Aubury, 1910). Originally, the Yuba River flowed in a deep "V" shaped gorge that may have been as deep as 75 feet. By the late 1890's, the Yuba River was choked with mining debris and the deep gorge had disappeared. Some natural sediments and probably also old hydraulic tailings continued to be transported to the lower Yuba River area from the time hydraulic mining was banned until 1941 when the Englebright Dam was completed.

In 1902 gold dredging began near the town of Hammonton and by 1910, 15 dredges were operating in the lower Yuba River (Au-

bury, 1910). The dredge tailing area has been dredged and re-dredged intermittently to the present time to progressively greater depths. This dredging of both the underlying natural alluvium and the hydraulic wash cover has produced a field of cobble windrows and linear pools of water. The windrows contain an enormous quantity of PCC-grade aggregate.

The active Yuba River channel within both the natural levees and man-made levees, contains unweathered gravels, sands, and silts. Since the completion of the Englebright Dam in 1941, only minor amounts of sand and gravel have been added from the tributaries below the dam.

Areas Classified MRZ-3

Areas classified MRZ-3 contain aggregate deposits of which the significance cannot be evaluated from available data. Sedimentary, metamorphic, and igneous rock types are included in this category. Evidence obtained from geologic literature or petrologic field investigations that shows a rock unit to contain abundant, hard, durable material without excessive amounts of deleterious materials is necessary for it to be considered a suitable candidate for an MRZ-3 classification. Additional information regarding the quality of material in these areas could either upgrade the classification to MRZ-2 or downgrade the classification to MRZ-1.

Many of the areas classified as MRZ-3 are located in hilly or mountainous terrain. These areas include undifferentiated metamorphic and igneous rocks — slate, quartzite, metaconglomerate, marble, metavolcanic rocks, serpentinite, metagabbro, diorite and monzonite. Other MRZ-3 areas are located in the Central Valley and are composed of Tertiary alluvial sediments. Stratigraphic relationships of these units are shown on Figure 8. Some areas that have been classified as MRZ-3 for PCC-grade aggregate may qualify for MRZ-2 for other commodities if further studies are made.

Areas Classified MRZ-4

Areas classified MRZ-4 are those areas for which available information is lacking or incomplete for assignment into the other MRZ categories. Areas classified MRZ-4 in the Yuba City-Marysville P-C Region have thick overlying soil layers which offer few rock exposures or are inaccessible.

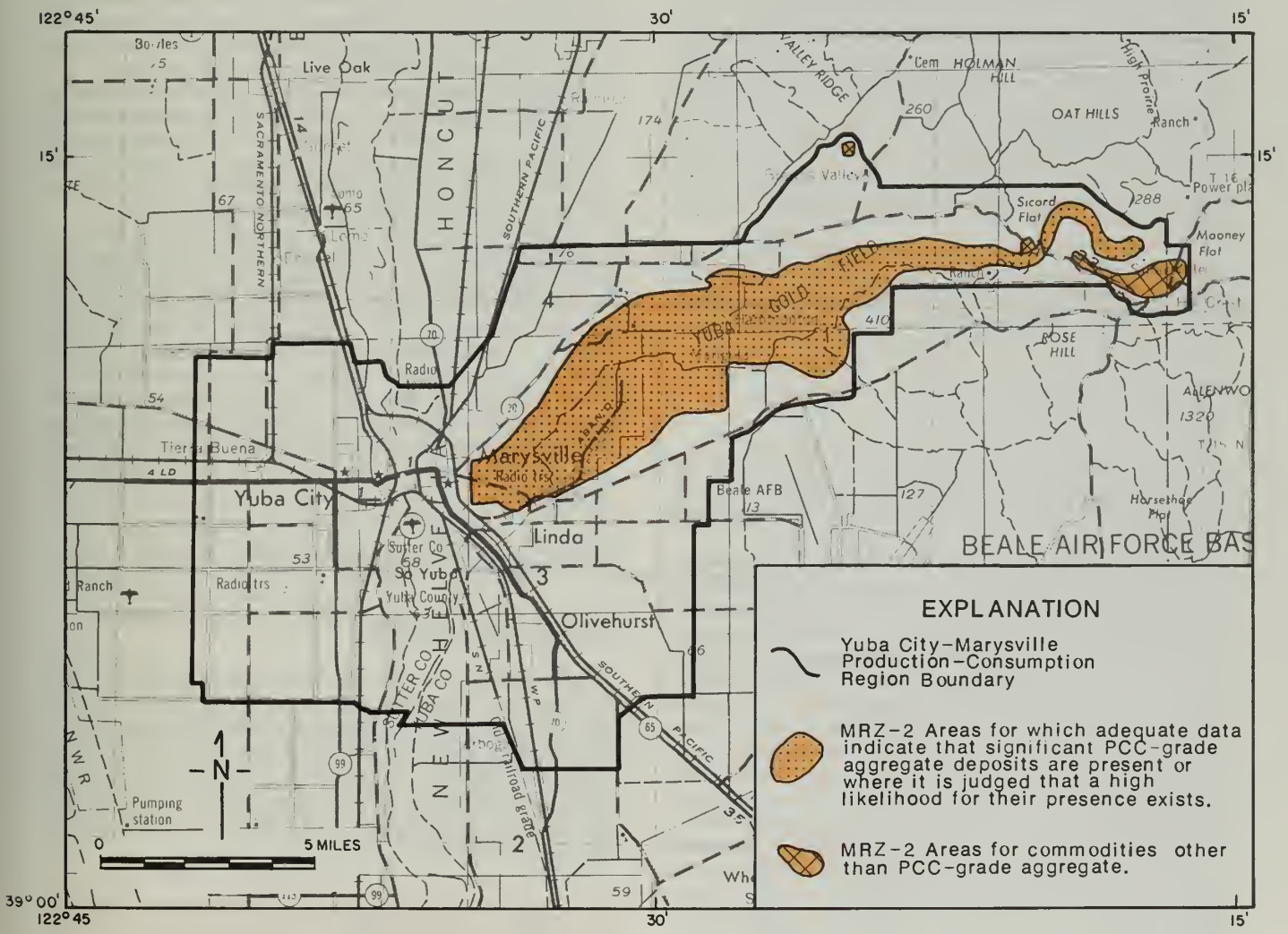

Figure 9. Areas classified os MRZ-2 in the Yuba City-Marysville Production-Consumption Region.

EVALUATION OF PCC AGGREGATE IN THE YUBA CITY-MARYSVILLE P-C REGION

An assessment of aggregate resources in the Yuba City-Marysville P-C Region is presented in this section of the report. The assessment was conducted on the basis of a quantitative evaluation of available, economically minable, aggregate resources. These aggregate resources must meet or exceed the State Mining and Geology Board's threshold value.

Concepts Used in Identifying Available Aggregate Resource Areas

The State Geologist is responsible for calculating aggregate resources for those areas classified MRZ-2. Recognizing that there are lands within MRZ-2 areas that have already been urbanized and therefore have a limited opportunity for mineral resource conservation and extraction, the State Geologist has limited the calculation of aggregate resource tonnages to portions of MRZ-2 areas that do not have current land uses incompatible with mining.

For purposes of classification, incompatible uses are urbanized lands containing improvements of high cost, such as high-density residential developments, intensive industrial developments, commercial developments, and major public facilities (see Appendix A, Interim Criteria for Sectorization of MRZ-2 Areas for Aggregate). Compatible uses are nonurbanized land comprised of very low density residential land (approximately one unit or less per 10 acres), recreational land that does not have high-cost improvements, agricultural land, silvicultural land, grazing land, and open space.

For this report, MRZ-2 areas were determined to be nonurbanized based upon land use prior to January 1986. Land use was determined by the authors after consultations with lead agencies, review of aerial photographs and photo-revised topographic maps, and field reconnaissance.

DEFINITION OF SECTORS

Sectors are areas that have been classified MRZ-2 by the State Geologist, and that are deemed to be available for mining based upon criteria for availability provided by the State Mining and Geology Board.

A sector is an area within which the geometrical configuration of the deposit is sufficiently regular to permit reliable calculation of the tonnage of the mineral resource present. Thus, for example, sector boundaries would be established between the part of a natural deposit formed on a fan, and that part within the confines of an adjacent modern stream channel and its floodplain. Mineral land classification, which is done without regard for current land use, results in a delineation of the resource areas on maps, but this by itself does very little to put into perspective the resource base that is available to meet the future needs of a region. Sectors have been employed to focus the attention of land planners and local governments on just those areas that remain accessible for mineral extraction. The State Geologist calculates the available resources of each sector, and identifies the amount of those resources that have been permitted for mining. These latter resources are termed reserves. The resources contained within non-sectorized MRZ-2 resource areas are not calculated because they are regarded as unavailable.

The calculated reserves and resources of all the sectors of the region are totaled and compared with the State Geologist's forecast of the 50-year needs of the region for aggregate resources. The comparison of regional needs with the available reserves and resources provides the opportunity to focus attention on the mineral resource issues confronting the region; *viz.* the need to plan carefully for the use of any lands containing mineral resources, and the need to consider the permitting of additional mining operations in the region as currently mined deposits are depleted.

Each sector meets or exceeds the Board's threshold values for deposits of significant size, and each sector may be considered for designation as an area of regional or statewide significance by the State Mining and Geology Board pursuant to Section 2790 SMARA. Areas that have not been sectorized by the State Geologist are not considered for designation by the Board.

Although the classification by the State Geologist and the designation by the Board are actions explicitly provided for by SMARA, and although the results of such actions yield reports that must be acted upon by affected local governments, the sectorization and sector maps (as opposed to the classification maps) do not of themselves carry with them specific obligations imposed on local governments by SMARA.

The sector maps and the resource base calculations, however, contain the essential facts that are needed to focus the attention of planners on the mineral availability problems and the alternative solutions to meet the mineral resource needs of the region. Without the sector maps and the accompanying calculations, the primary objectives of SMARA could not be achieved.

Because the Board's criteria for sectorization focus on the apparent suitability of the land for mining and do not take into account commitments that may have been made to restrict the accessibility of some of the sectors for mining, it is possible that the available resource base as calculated by the State Geologist may be overestimated and the problems confronting local government may be understated. Considering these possibilities, it becomes important for local governments to carefully review the sectors and the associated estimates of resources to ensure that previously unrevealed problems are not overlooked and that planning decisions are made using a correct perspective on available resources.

Calculation of Available Resources

RESERVES AND RESOURCES

In this report, *reserves* are estimates of tonnages of aggregate that have been determined to be acceptable for commercial use, that exist within properties owned or leased by aggregate producing companies, and for which permits have been granted to allow mining and processing of the material. *Resources* include *reserves* as well as all similar potentially usable aggregate materials that may be mined in the future, but for which no permit allowing mining has been granted.

FACTORS CONSIDERED IN CALCULATIONS

The resource estimates given here are limited to those PCC-grade aggregate resources present in resource sectors, which are, as explained in the previous section, the nonurbanized portions of the areas classified MRZ-2. The two resource sectors defined in this study are shown on the sector maps (Plates 9-11) that accompany this report. The sectors are identified by the letters A and B on the sector maps and in the sector descriptions that follow. The sectors are subdivided into numbered subsectors to recognize the locations of roads, bridges, dams, major powerlines and major pipelines. Subsectors A-1 through A-9 identify resource areas in the Yuba River dredge field and Subsectors B-1 through B-9 delineate resource areas along the Yuba River west of the dredge field.

The following factors were used to determine the areal extent and tonnage of PCC-grade aggregate resources within the two sectors:

1. Sector resource tonnage estimates were based on measurements taken from base maps that have a scale of 1:24,000.
2. Even in proven PCC-grade aggregate deposits, a small percentage of the aggregate cannot be used in concrete and is referred to in this study as "waste." Waste includes pit-run waste and production waste. The waste factors for untested sector areas were estimated using data from water-well logs and idealized cross sections. Waste percentages were often extrapolated to deposits in untested sector areas from reports from nearby aggregate pit operators.
3. Thicknesses of PCC-grade deposits were determined by water-well log data, geologic literature and interviews with knowledgeable aggregate professionals.
4. Setback considerations, adopted from lead agency mining ordinances, were used in determining the areal limits of sectors that border areas not available for mining.

Resource Sector Descriptions

The total area of the resource sectors in the Yuba City-Marysville P-C Region is 22.8 square miles, of which 10.3 square miles are currently permitted for mining. As previously noted, sectors are delineated only within areas classified MRZ-2 that are available for mining. The estimated total of PCC-grade aggregate resources in the two sectors is 2.25 billion tons. As of 1985, 1.26 billion tons of these resources were permitted for mining and therefore qualified as reserves. A summary of the data for Sectors A and B is shown on Table 3.

The resource sectors are described below:

SECTOR A

Sector A covers over 8,400 acres of dredge tailings and river channel area where the Yuba River flows into the Central Valley. Five aggregate mining companies control most of the sector, with Yuba Natural Resources, Inc. owning the largest part. Baldwin Contracting Co. has been mining in the western part of the sector since 1958. Teichert Aggregates began operations in the Yuba River dredge field in the 1960s. Trinco, Inc. mined in this sector from 1978-1980 and recently started up again in 1985. Yuba Natural Resources, Inc. and Centex Aggregates, Inc. are not active at present. Two other aggregate companies, Placer Resources, Inc. and Garcia Sand and Gravel, operate plants on Yuba Natural Resources property. Placer Resources, Inc. is in joint venture with Yuba Natural Resources, Inc. The sector consists almost entirely of dredge tailings which make up the Yuba River dredge field. Small undredged areas of the stream channel are included in the upstream portion of the sector in Subsectors A-7, A-8 and A-9. Average minable aggregate thickness is directly related to the depth of gold dredging and varies from 20 feet to over 100 feet. The opinion shared by many of the operators is that dredging removes much of the fines (silt) and breaks down and washes out the softer material. The windrows which have been formed from the dredging appear to be composed exclusively of cobbles when in reality over 50 percent of the aggregate in the windrows is less than 3 inches in size. Further information on the makeup and quality of the dredge tailings can be found in Appendices B through E. The estimated waste in the dredge tailings is 15 percent by volume as judged from the mining operation at the Baldwin Contracting Company's Hallwood pit. The density of the dredge tailings is estimated at 1.4 tons per cubic yard by Yuba Natural Resources, Inc. The estimated total of PCC-grade reserves in Sector A is 1,215 million tons, and the total resource is 1,301 million tons.

A-1: Subsector A-1 consists of approximately 1,312 acres lying both north and south of the Yuba River, from the western edge of the dredge tailings to the power transmission line which stands about 1 mile to the east. The entire subsector consists of dredge tailings. An average minable aggregate thickness of 80 feet and a waste factor of 15 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. The entire subsector is permitted for mining by five aggregate companies: Baldwin Contracting Co., Inc., Centex Aggregates, Inc., Teichert Aggregates, Trinco Inc., and Yuba Natural Resources, Inc. The estimated total PCC-grade aggregate resource is 184.6 million tons and the reserve total is 167.9 million tons.

A-2: Subsector A-2 consists of about 1086 acres lying both north and south of the Yuba River adjacent to Subsector A-1 to the west. This area is bounded by two power transmission lines which are 1/2- to 3/4-of-a-mile apart. The entire subsector consists of dredge tailings with an average minable aggregate thickness of 80 feet. A waste factor of 15 percent was used to calculate the total tonnage of PCC-grade aggregate in this subsector. The subsector is permitted for mining by Teichert Aggregates, Baldwin Contracting Co., and Yuba Natural Resources, Inc. The PCC-grade aggregate resource and reserve totals are confidential.

A-3: Subsector A-3 consists of about 36 acres lying north of the Yuba River and about 1/4-mile south of Spring Valley Road. The entire subsector consists of dredge tailings in which the average minable depth of PCC-grade aggregate is 80 feet. A waste factor of 15 percent was used to calculate the tonnage of aggregate. Nearly 1/3 of the sector is permitted for mining by Teichert Aggregates, even though no mining is being done at this time. The estimated PCC-grade aggregate resource is 5 million tons. The reserve total is confidential.

A-4: Subsector A-4 consists of about 38 acres lying south of the Yuba River and to the east of Subsector A-2. It is about 1 mile west of Hammonton Road. The entire subsector consists of dredge tailings. An average minable aggregate thickness of 80 feet and a waste factor of 15 percent were used in calculating the total PCC-grade aggregate tonnage. The entire subsector is permitted for mining by Yuba Natural Resources,

TABLE 3. Data on sectors in the Yuba City-Marysville P-C Region.

SECTOR	DENSITY TONS/CU YD	WASTE %	DEPTH FEET	AREA ACRES	RESERVES MILLION TONS	RESOURCES + MILLION TONS
A-1	1.4	15	80	1312	167.9	184.6
A-2	1.4	15	80	1086	*	*
A-3	1.4	15	80	36	*	5.0
A-4	1.4	15	80	38	*	*
A-5	1.4	15	80	2511	*	382.9
A-6	1.4	15	120	1690	*	*
A-7	1.4	15	70	1373	*	*
A-8	1.55	15	20	329	*	14.0
A-9	1.55	15	20	57	0	2.4
			Sub Totals	8,432	1,215.3	1,300.8
B-1	1.7	15	50	57	0	6.0
B-2	1.7	15	60	561	*	75.7
B-3	1.7	15	50	25	0	2.5
B-4	1.7	15	50	1051	*	119.9
B-5	1.7	15	80	3372	*	610.0
B-6	1.7	15	20	10	0	0.4
B-7	1.7	15	60	279	0	35.7
B-8	1.7	15	50	809	*	93.3
B-9	1.7	15	50	11	0	1.1
			Sub Totals	6,175	46.3	944.6
			GRAND TOTALS	14,607	1,261.6	2,245.4

+ includes reserves
* cannot be shown due to confidentiality

Inc., but no mining is being done at this time. The aggregate resource and reserve total is confidential.

A-5: Subsector A-5 consists of about 2,511 acres along the Yuba River both to the north, south, and west of Daguerra Dam. The entire subsector consists of dredge tailings. An average minable aggregate thickness of 80 feet and a waste factor of 15 percent were used in calculating the total PCC-grade aggregate tonnage. Nearly all of the subsector is permitted for mining by Teichert Aggregates in the northern part, and Yuba Natural Resources Inc. in the remainder. Yuba-Placer Gold Company is dredging for gold on Yuba Natural Resources property. Yuba-Placer Gold Company does not market aggregate as a co-product from its dredging operation. The estimated PCC-grade aggregate resource is about 383 million tons. The aggregate reserve figure is confidential.

A-6: Subsector A-6 consists of about 1,690 acres along the Yuba River with the majority of the subsector lying south of the river and east of Daguerra Dam. All of the minable aggregate in the subsector is dredge tailings. An estimated average minable aggregate thickness of 120 feet and an average waste factor of 15 percent were used to calculate the total tonnage of PCC-grade aggregate in the subsector. Over 95 percent of the subsector is permitted for mining by Yuba Natural Resources, Inc. Placer Resources, Inc. is producing aggregate in this subsector. The estimated PCC-grade aggregate resource and reserve for Subsector A-6 is confidential.

A-7: Subsector A-7 consists of about 1373 acres along the Yuba River. The minable aggregate in the subsector is nearly all dredge tailings with some river channel deposits. The majority of this subsector is permitted for mining. An average minable aggregate thickness of 70 feet and an average waste factor of 15 percent were used to calculate the total tonnage of PCC-grade aggregate in the subsector. There is one aggregate producer in the subsector — Garcia Sand and Gravel. The total PCC-grade aggregate resource and reserve for Subsector A-7 is confidential.

A-8: Subsector A-8 consists of about 329 acres along the Yuba River channel at Timbuctoo Bend. The minable aggregate resources consist of about half river channel deposits and half dredge tailings. The density of the undredged material is assumed to be similar to the material in Sector B (1.7 tons per cubic foot) and therefore, an averaged density factor of 1.55 tons per cubic yard was used to calculate the combined materials. An estimated minable resource depth of 20 feet and an estimated waste factor of 15 percent were used to calculate the total tonnage of PCC-grade aggregate in the subsector. Yuba Natural Resources, Inc. owns part of the subsector. The estimated total PCC-grade aggregate resource is 14 million tons. The reserve figure is confidential.

A-9: Subsector A-9 consists of about 57 acres along the Yuba River at Rose Bar. The minable aggregate resource consists of about half river channel deposits and half dredge tailings. As in Subsector A-8, an average density factor of 1.55 tons per cubic yard was assumed for the resource calculations. An estimated minable resource depth of 20 feet and an estimated waste factor of 15 percent were used to calculate the total tonnage of PCC-grade aggregate in the subsector. The estimated resource is about 2 million tons. Although it is below the threshold value set by the State Mining and Geology Board the aggregate resource in Subsector A-9 can be mined in conjunction with the resource in Subsector A-8.

SECTOR B

Sector B covers nearly 6,200 acres and includes the Yuba River channel and floodplain southwest of the dredge tailings to the confluence with the Feather River. The gravel deposits are located throughout the river channel and floodplain, and the sand deposits are located in the old river channels. Gravels underlie the sand at an average depth of 35 feet. Hydraulic wash from upstream monitor operations during the late 1800s may have been deposited on the surface of parts of the floodplain in Sector B. Currently operators are under a restriction by Yuba County to mine only to a depth of 50 feet below grade. Average minable aggregate thickness ranges from 20 feet to 80 feet. A density of 1.7 tons per cubic yard is reported by Linda Sand and Gravel Co. and was used in calculating the resources for Sector B. Estimated waste is 15 percent by volume. Although the aggregate plants in Sector B report a lower waste percentage, a study of the drill logs in the area show clay layers in the sector that would cumulatively raise the waste fraction when large areas are considered. The figure of 15 percent was chosen as a conservative estimate, as it is expected that the material in Sector B could contain as large a fine fraction as Sector A which lies immediately upstream. The majority of the material mined in this sector is sand due to the permitting limitations on depth of mining. There are six aggregate companies with permitted property in this sector. Four of the companies, Baldwin Contracting Co., Centex Aggregates, Inc., Yuba Natural Resources, Inc., and Trinco, Inc. have only small holdings which extend into Sector B from their major holdings in Sector A. The remaining two companies Quinco, Inc. and Linda Sand and Gravel Co. mine aggregate in Sector B. Quinco has been in operation here since about 1973 and Linda Sand and Gravel started mining here in 1979. The estimated total of PCC-grade aggregate reserves in Sector B is

approximately 46 million tons, and the resource is about 945 million tons.

B-1: Subsector B-1 consists of about 57 acres and is bounded by a levee on the north and south, the Southern Pacific Railroad track on the east and highway 70 on the west. An average minable aggregate thickness of 50 feet and a waste factor of 15 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. Yuba River Sand Co. ceased mining sand in this subsector in 1980. The estimated total PCC-grade aggregate resource is about 6 million tons. There are no reserves in Subsector B-1.

B-2: Subsector B-2 consists of about 561 acres and is bordered by Simpson Lane on the north and east, a levee and the Southern Pacific Railroad tracks on the south, and the City of Marysville on the west. An average minable aggregate thickness of 60 feet and a waste factor of 15 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. Linda Sand and Gravel Co. is the only operator in this sector. The estimated total PCC-grade aggregate resource is about 76 million tons. The reserve estimate is confidential.

B-3: Subsector B-3 consists of 25 acres and is bordered by the levee to the north, Hammonton-Smartville Road to the east, North Beale Road to the south and Gosset Way to the west. An average minable aggregate thickness of 50 feet and a waste factor of 15 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. There has been no mining in this subsector. The estimated total PCC-grade aggregate resource is about 3 million tons.

B-4: Subsector B-4 consists of about 1,051 acres and is bordered by a levee to the north, a power line to the east, Peach Tree Golf and Country Club to the south and Simpson Lane to the southwest. An average minable aggregate thickness of 50 feet and a waste factor of 15 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. Quinco, Inc. is the only operator in this subsector. The estimated total PCC-grade aggregate resource is about 120 million tons. The reserve total is confidential.

B-5: Subsector B-5 is an irregularly shaped area consisting of about 3,372 acres. It is generally bordered by a power line on the west, the Yuba River levee and Powell Road on the north, the dredge tailings on the east, and the levee south of the Yuba River on the south. The levee along the river and Plantz Road are excluded from the sector. An average minable aggregate thickness of 80 feet and a waste factor of 15 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. Trinco, Inc. is an active operator in this subsector and Centex Aggregates, Inc. has a permit but has not yet begun production. Estimated total PCC-grade aggregate resource is about 610 million tons. The reserve figure is confidential.

B-6: Subsector B-6 consists of 10 acres and is located just east of the intersection of Simpson-Dantoni Road and south of the levee on the southern side of the Yuba River. An average minable aggregate thickness of 20 feet and a waste factor of 15 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. There has been no mining in this subsector. The estimated total PCC-grade aggregate resource is about 0.4 million tons. Although this is less than the threshold value set by the State Mining and Geology Board, the material in this subsector can be mined in conjunction with the material in Subsector B-5.

B-7: Subsector B-7 consists of about 279 acres and is approximately 1/4-mile wide, extending from the extreme southeast corner of the dredge tailings for approximately 2 miles along the south side of the levee on the southern side of the Yuba River. An average minable aggregate thickness of 60 feet and a waste factor of 15 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. There has been no mining in this subsector. The estimated total PCC-grade aggregate resource is about 36 million tons. There are no reserves in this subsector.

B-8: Subsector B-8 consists of about 809 acres and is generally bordered by the dredge tailings on the east, Hooper Road on the north, and the Yuba River channel on the south. Hallwood and Walnut Avenues are excluded from the sector. An average minable aggregate thickness of 50 feet and a waste factor of 15 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. Baldwin Contracting Co., Centex Aggregates, Inc., Trinco, Inc., and Yuba Natural Resources, Inc. have very small holdings in Subsector B-8 which extend from their major holdings in Sector A. There has been no mining in this subsector. The estimated total PCC-grade aggregate resource is about 93 million tons. The reserve total is confidential.

B-9: Subsector B-9 consists of 11 acres and is located in an area approximately 500 feet wide between Walnut Avenue and Hooper Road and east of Hallwood Boulevard. An average minable aggregate thickness of 50 feet and a waste factor of 15 percent were used to calculate the total tonnage of PCC-grade aggregate in this subsector. There has been no mining in this subsector. The estimated total PCC-grade aggregate resource is 1 million tons. Although it is below the threshold value set by the State Mining and Geology Board, this deposit can be mined in conjunction with the material in Subsector B-8.

CLASSIFICATION OF OTHER MINERAL COMMODITIES

Since the onset of the Urban SMARA Program, it has been the policy of DMG under the SMARA guidelines to concentrate its classification effort on deposits capable of producing PCC-grade aggregate. While this policy still guides the SMARA Program, it has been modified recently so that all active mining operations within the P-C region will be classified MRZ-2 for the specific commodity they produce, even though the entire region will not have been systematically classified for those commodities. Geologic deposits being developed by these active mines must still meet all SMARA guidelines and classification criteria for signif-

icance (demonstrated marketability and threshold values). Non-PCC-grade aggregate deposits classified MRZ-2 in this report have met all classification criteria specified in the guidelines and are shown on the accompanying plates with the symbol MRZ-2 followed by parentheses showing the specific commodity classified. Because no effort has been made to establish the regional or statewide significance of these active mines, they have not been sectorized and their reserves have not been quantified beyond the point where minimum threshold value was established. They are, consequently, not put forward as candidates for designation by the State Mining and Geology Board.

The Yuba City-Marysville P-C Region has six producers of commodities other than PCC-grade aggregate which the authors have classified MRZ-2. They are mining three different types of deposits, Jurassic metavolcanic rocks, Tertiary stream channel deposits, and the Yuba River dredge field.

The metavolcanic bedrock, which is exposed in the eastern portion of the study area has been classified MRZ-2 for riprap in two places.

- Sperbeck Quarry, operated by Carl J. Woods is located on the south side of Spring Valley Road, approximately 2½ miles northeast of Highway 20 and 2000 feet south of the Old Spring Valley School (Plate 1). The deposit, consisting of greenstone, has been classified MRZ-2 for riprap material. The mine, which was started in 1955, has not been active for the past two years, but has a conditional use permit valid until August 1986. The deposit was classified for riprap because the bulk of the produced material is sold for that use, although base, subbase, and fill are also marketed. Test data necessary to upgrade the deposit to MRZ-2 for PCC-grade aggregate is lacking.
- Parks Bar Quarry, operated by Claude C. Wood Company, is located on the north side of the Yuba River approximately 500 feet east of Parks Bar Bridge on State Highway 20 (Plate 5). The deposit consists of amphibolite and has been classified MRZ-2 for riprap. The lease to mine was granted in 1955 and there was subsequently over 15 years of production. The mine began production again in 1987. This deposit was classified MRZ-2 for riprap because the bulk of its production is sold for that use, although base, subbase, and fill are also marketed. Test data necessary to upgrade the deposit to MRZ-2 for PCC-grade aggregate is lacking.

The Tertiary stream channel deposits in the Timbuctoo area have been classified MRZ-2 for base and subbase. The deposits consist of weathered gravels, sands, and silts that were deposited by the ancestral Yuba River system. Parts of the gravels were hydraulically mined for gold in the late 1800's. Three aggregate companies are located on these deposits.

- River Rock Construction, Inc., operated by Clyde Clark, is located 1/4-mile east of Smartville Road, in Smartville (Plate 5). The deposit, consisting of Tertiary gravels, has been classified MRZ-2 for base material. Tests conducted by Caltrans has indicated that the material meets all necessary specifications for base, though it is too soft for use as PCC-grade aggregate. The mine is currently active and has been operating at this site for over five years. The majority of the production is sold outside the P-C region. This deposit is at the site of the Old Blue Point Mine which still has remnants of the hydraulic mining which occurred prior to 1900. The operators are exploring the possibility of gold recovery as a co-product.
- Black Swan Mine, proposed by Black Swan Associates, is located in Nevada County (adjacent to the Yuba County line) approximately 15 miles west of Grass Valley (Plate 5). The property is sited in a rural area about 1/4-mile west of the community of Mooney Flat and 1.5 miles east of Smartville. The deposit consists of Tertiary gravels and will be mined for subbase and/or base material and possibly gold. Test data indicates that the deposit meets specifications for subbase and/or base, so it has been classified MRZ-2 for those commodities. The proposed mining site shows remnants of the hydraulic mining which occurred prior to 1900.
- Timbuctoo Mine, operated by Jim Ashenbrenner, is located at Timbuctoo Bend 1.5 miles northwest of Smartville (Plate 5). The deposit is currently being mined for aggregate base and consists of Tertiary gravels from the old Tertiary river channel which runs from Mooney Flat through Smartville and Timbuctoo to Sicord Flat. This deposit has not been tested directly but the same gravels located at the Blue Point Mine (currently being mined by River Rock Construction, Inc.) were tested and proved too soft for PCC-grade aggregate. For these reasons, the deposit has been classified MRZ-2 for base material. The mining operation is currently permitted but not yet operational. Tests have been run on the gold content of the gravels and results indicate that gold can be economically produced as a co-product. The mining operation of aggregate and gold should begin very soon. The project area is also the site of several old gold mines which were active prior to the 1900s.

Parts of the Yuba River dredge tailings are also classified MRZ-2 for gold, as well as for PCC-grade aggregate. Presently one company is mining the dredge tailings for gold.

- The Yuba-Placer Gold Company gold dredge is located west of Hammonton and north of Hammonton-Smartville Road (Plate 4). The deposit consists of the Yuba River dredge tailings. This deposit is currently classified MRZ - 2 for PCC - grade aggregate and is indicated as Sector A. The sector is also classified MRZ - 2 for gold. The Yuba-Placer Gold Company is part of a joint venture with Yuba Natural Resources, Inc., which is currently dredging the old tailings along with virgin ground underneath the old tailings. The dredge produces gold with PCC-grade aggregate as a by-product. The area that the joint venture covers is approximately 2,000 acres and approximately 1,400 ounces of gold is produced monthly (Silva, 1986). The dredging operation has been running almost continuously since 1902 and is planned to continue for many more years.

ESTIMATED 50-YEAR CONSUMPTION OF AGGREGATE

Basis of 50-Year Forecasts

The State Mining and Geology Board, as specified in its "Guidelines for Classification and Designation of Mineral Land" (Part II of Division of Mines and Geology Special Publication 51), requires that mineral land classification reports for regions containing construction materials classified MRZ-2 include, "An estimate of the total quantity of each such construction material that will be needed to supply the requirements of both the county and the marketing region in which it occurs for the next 50 years. The marketing region is defined as the area within which such material including aggregate is usually mined and marketed. The amount of each construction material mineral resource needed for the next 50 years shall be projected using past consumption rates adjusted

for anticipated changes in market conditions and mining technology." In the "Guidelines" the Board also specifies that these estimates be reviewed periodically (every 10 years or less).

Fifty-year forecasts of PCC-grade aggregate needs in the Yuba City-Marysville P-C Region were made on the basis of reported aggregate production records during the years 1964-1984. For the purposes of this study it was determined that an average of 55 percent of all aggregate produced in the Marysville area has been consumed outside the study area from 1980 to 1984, and that imports of PCC-grade aggregate from outside the study area are insignificant. About 42 percent of the aggregate has gone to the Sacramento area to the south and about 10 percent to the Foothill area to the east (Figure 4).

Correlations Between Aggregate Production and Consumption

Past studies of aggregate marketing regions in California have shown that there is a strong correlation between the amount of aggregate produced and the population in a given aggregate production-consumption area (Anderson and others, 1979). On this basis, aggregate production and population figures in the Yuba City-Marysville P-C Region were correlated for the years 1964 through 1984. Correlations between the annual aggregate production records and the population statistics were used to obtain per capita consumption rates of aggregate in the study area. The historical aggregate production data in the study area was obtained from mining records of the U.S. Department of the Interior, Bureau of Mines (1964 through 1984). The historical population data for the Yuba City-Marysville area was taken from the 1960, 1970, and 1980 census data published by the U.S. Bureau of the Census; by using the census tract information along with the past growth rate (Yuba Planning Department), the population for the intermediate years was estimated (Table 4 and Figures 10 and 11).

The average per capita consumption rate in the Yuba City-Marysville P-C Region is 5.4 tons of aggregate per year over the 20-year period from 1964 to 1984. The low consumption rates in the Yuba City-Marysville area are probably due to the low growth rate in the region. At the time of this writing, the area has a 1-2 percent annual growth rate (Yuba County Planning Department). The low consumption rate probably will be maintained unless a higher growth rate occurs in the Yuba City-Marysville area.

Projected Population and Per Capita Consumption to the Year 2035

A simple analysis of the historical aggregate production and population statistics was conducted to forecast basic trends in the per capita consumption rate of aggregate within the Yuba City-Marysville area to the year 2035. The total aggregate needs of the study area to the year 2035 were calculated on the basis of two factors: (1) a projected average annual per capita consumption rate of 5.4 tons (the average per capita consumption rate for the years 1964 to 1984) and the projected population of the region for future years to the year 2035. Population projections for the years 1985 to 2020 were obtained from the California Department of Finance (1983). This data was extrapolated for the study area on a straight line basis to the year 2035 to provide the 50-year population projection as specified under the SMARA guidelines (Figure 12). The results of these calculations reveal that an estimated 26.5 million tons of aggregate of all types will be needed to satisfy the projected future demand for this construction material in the Yuba City-Marysville P-C Region to the year 2035, and that 7.7 million tons of this material must be PCC-grade (Tables 5 and 6).

TABLE 4. Aggregate production, population, and per capita consumption record of the Yuba City-Marysville Production-Consumption Region for the years 1964-1984.

YEAR	TOTAL PRODUCTION (Tons)	PRODUCTION EXPORTED (Tons)	PERCENT EXPORTED	PRODUCTION CONSUMED LOCALLY (Tons)	TOTAL P-C REGION POPULATION	PER CAPITA CONSUMPTION (Tons/ Person/Yr)
1964	711,000	331,000	45%	380,000	59602	6.4
1965	601,000	310,000	50%	291,000	60204	4.8
1966	624,000	342,000	55%	282,000	60812	4.6
1967	914,000	413,000	45%	501,000	61426	8.2
1968	553,000	286,000	50%	267,000	62047	4.3
1969	488,000	197,000	40%	291,000	62674	4.6
1970	529,000	199,000	40%	330,000	63307	5.2
1971	463,000	168,000	35%	295,000	63947	4.6
1972	601,000	210,000	35%	391,000	64593	6.0
1973	431,000	175,000	40%	256,000	65245	3.9
1974	661,000	273,000	40%	388,000	65904	5.9
1975	529,000	220,000	40%	309,000	66570	4.6
1976	489,000	184,000	40%	304,000	67242	4.5
1977	612,000	213,000	35%	399,000	67921	5.9
1978	835,000	371,000	45%	464,000	68607	6.8
1979	1,084,000	535,000	50%	549,000	69300	7.9
1980	966,000	562,000	58%	404,000	70000	5.8
1981	845,000	457,000	54%	388,000	70700	5.5
1982	746,000	432,000	58%	314,000	71407	4.4
1983	716,000	362,000	50%	354,000	72121	4.9
1984	864,000	474,000	55%	390,000	72842	5.4

AVERAGE P-C REGION PER CAPITA CONSUMPTION = 5.4 TONS/PERSON/YEAR

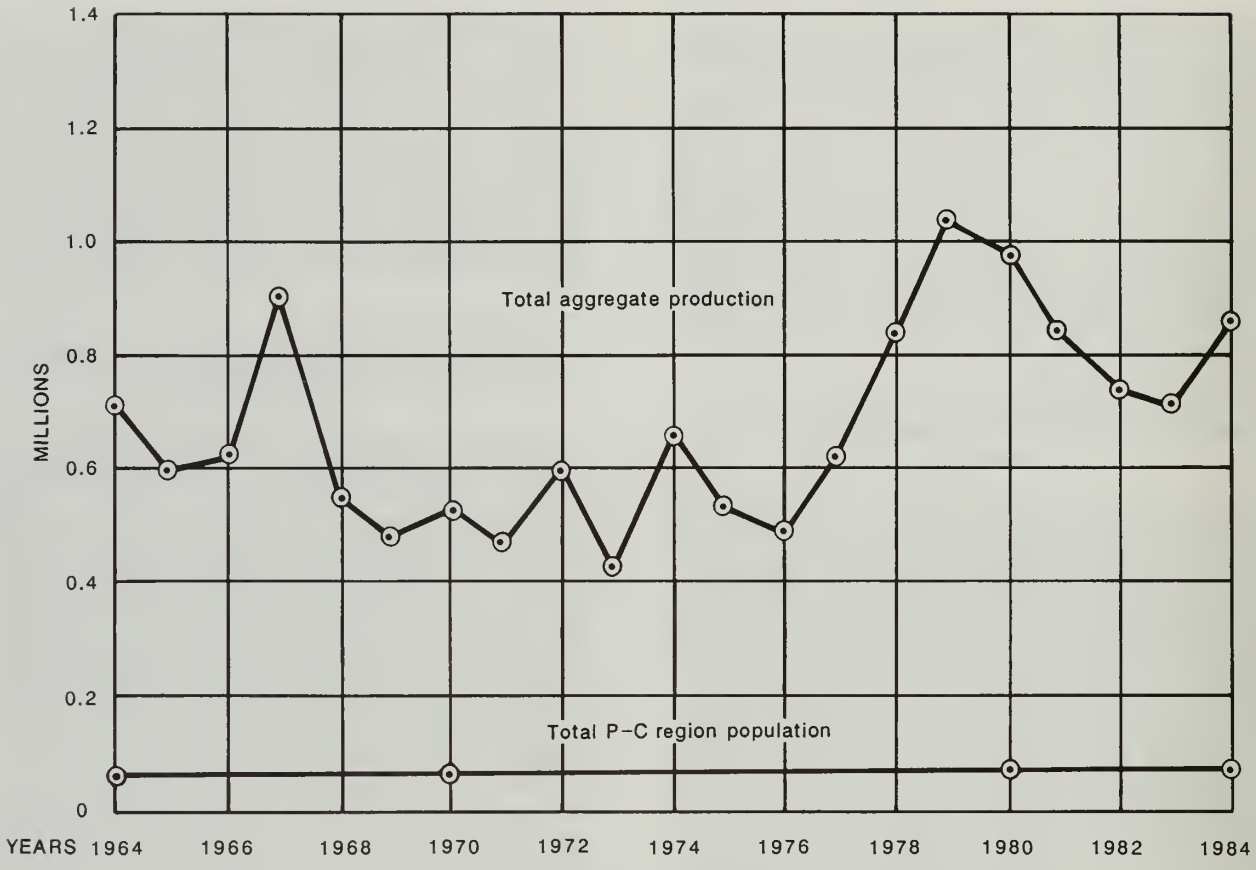

Figure 10. Yuba City-Morysville P-C Regian: Populatian and aggregate consumption record, 1964-1984.

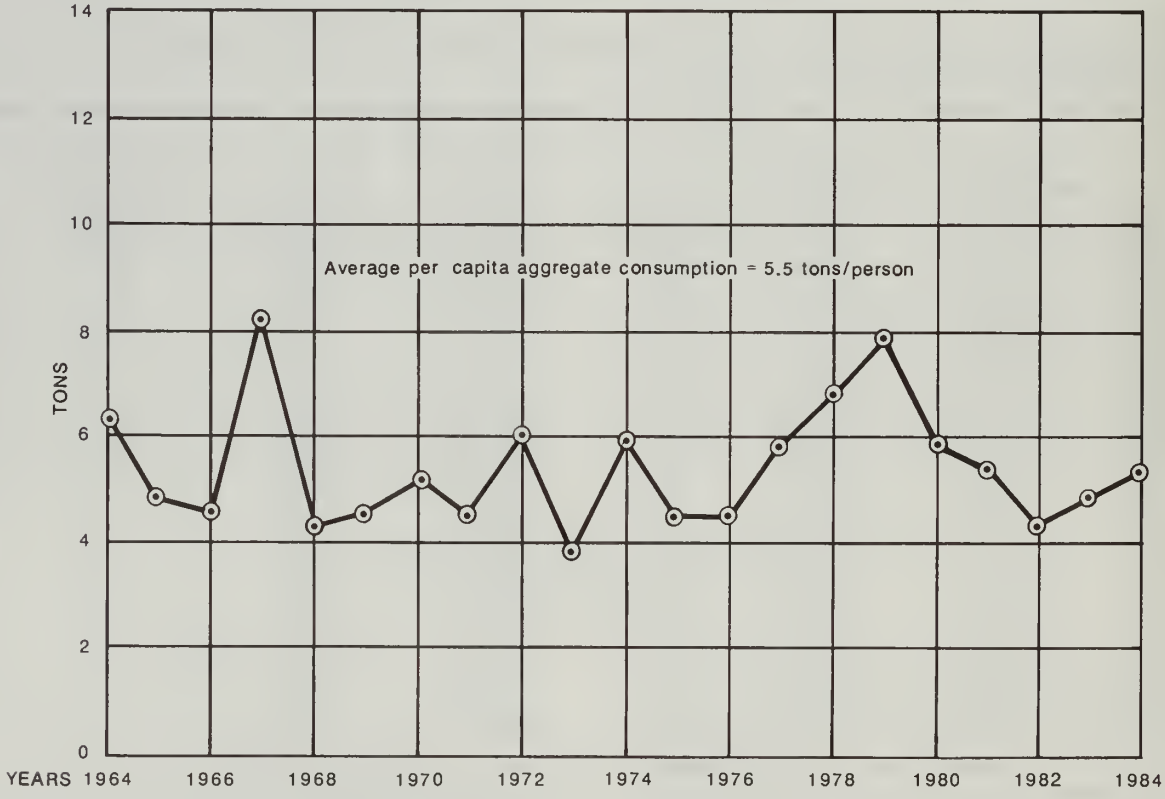

Figure 11. Yuba City-Morysville P-C Region: Annual per capita cansumptian of aggregote, 1964-1984.

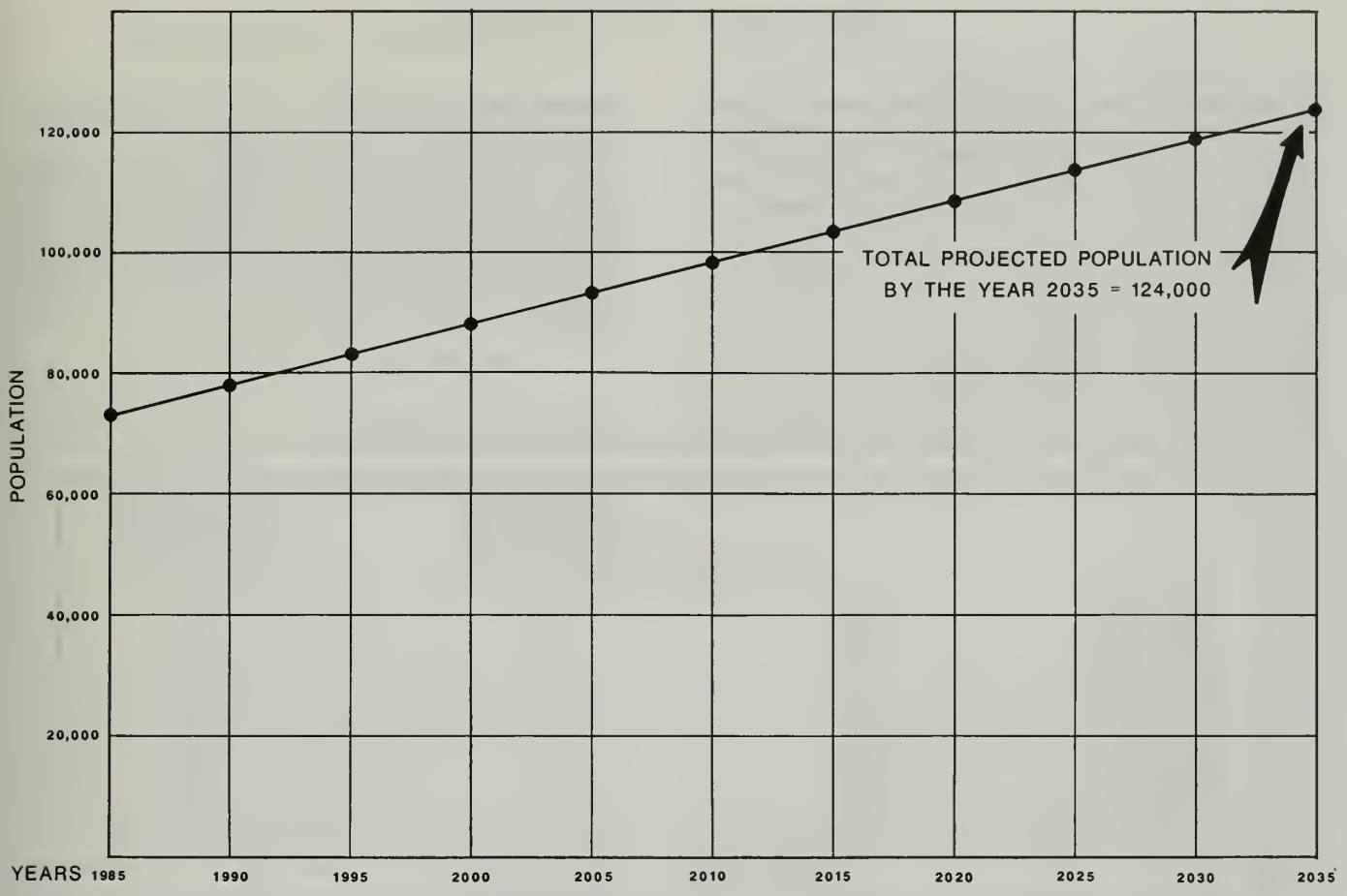

Figure 12. Projected populotion of the Yubo City-Morysville P-C Region for the yeors 1985-2035.

Factors Affecting Per Capita Consumption Rates

The wide variations from year to year in the per capita consumption rate (Table 4; 3.9 to 8.2 tons per person per year) are probably reflections of changes in urban growth rates with time, or reflections of the occurrence of major construction projects (for example, freeways). In part, these variations may result from incomplete and inaccurate production records supplied by the mine operators to the U.S. Bureau of Mines. Certainly the economic climate is a powerful variable that influences the annual per capita consumption rate for aggregate. Very high interest rates, for example, such as existed in California during the 1980 to 1982 period, tend to lower the amount of new construction in an area and, consequently, lower the demand for aggregate.

Based on the low growth rates anticipated in the Yuba City-Marysville P-C Region, the average annual per capita consumption rate of 5.4 tons will probably remain until the onset of a more rapid rate of urban growth and then perhaps increase. However, should unforeseen events occur, such as disaster reconstruction, or a major recession, the per capita consumption rate could change radically.

Comparison of the 50-Year Aggregate Demand with Current Reserves

The total PCC-grade aggregate reserves for the Yuba City-Marysville P-C Region are estimated to be 1,262 million tons. At the average rate of past aggregate consumption in the region (5.4 tons per person annually), a total of 26.5 million tons of aggregate will be needed to satisfy local demand for the next 50 years. Clearly, the abundant reserves of the Yuba River resource area are sufficient to easily supply the Yuba City-Marysville P-C Region.

To help illustrate the excess amount of aggregate available in the Yuba River deposit, it has been projected that not only could the deposit supply the Yuba City-Marysville P-C Region, but also could supply the Sacramento P-C Region for the next 50 years, even if Sacramento were to stop its production today. Even further, the total projected aggregate demands of the entire San Francisco Bay-Monterey Bay area, the Sacramento area, and the Yuba City-Marysville area can be met by the Yuba City-Marysville P-C Region reserves.

According to U.S. Bureau of Mines aggregate production statistics for the years 1964 to 1984 and information from aggregate operators in the Yuba City-Marysville P-C Region, roughly 29 percent of the total aggregate consumed in the study region has been used for PCC (Table 6). If the region continues to require the same percentage of PCC aggregate, the total amount of PCC aggregate that would be needed to supply the Yuba City-Marysville area to the year 2035 is estimated to be 7.7 million tons. Approximately 1,262 million tons of PCC-grade aggregate reserves currently exist in the study area.

ALTERNATIVE SOURCES OF AGGREGATE

The enormous tonnage of PCC-grade aggregate reserves, coupled with limited local consumption, makes it unlikely that alternative sources will need to be utilized to satisfy the needs of the Yuba City-Marysville P-C Region in the forseeable future. However, several alternative sources do exist. Potential sources of PCC-grade aggregate, in addition to the deposits classified MRZ-2, exist within the Yuba City-Marysville P-C Region. These potential sources lie within areas that are classified MRZ-3, and include volcanic, granodioritic, and metamorphic bedrock. In addition, untested MRZ-3 alluvial deposits that may provide alternative sources of PCC-grade aggregate in the study area are found in alluvial channel deposits, and in beds of the Riverbank and Modesto formations.

Another potential source of PCC-grade aggregate is the ground occupied by Beale Air Force Base. The Base is underlain by large resources of Riverbank Formation, which is a source of high-quality aggregate elsewhere in the P-C region. Politically, and practically the deposits under Beale are very unlikely to be made available for mining in the near future. However, if conditions change at some future time, these deposits should not be overlooked.

TABLE 5. Projected aggregate consumptian ta the year 2035 far the Yuba City-Marysville P-C Regian.

YEARS	POPULATION	AGGREGATE CONSUMPTION ALL AGGREGATE (Million Tons)	AGGREGATE CONSUMPTION PCC AGGREGATE (Million Tons)
1985-1990	78,000	2.1	0.61
1990-1995	82,000	2.2	0.64
1995-2000	86,000	2.3	0.67
2000-2005	90,000	2.4	0.70
2005-2010	95,000	2.6	0.75
2010-2015	100,000	2.7	0.78
2015-2020	105,000	2.8	0.81
2020-2025	110,000	3.0	0.87
2025-2030	116,000	3.1	0.90
2030-2035	122,000	3.3	0.96
TOTAL AGGREGATE = 26.5 Millian Tons			
TOTAL PCC AGGREGATE = 7.7 Millian Tans			

*TABLE 6. Portland cement concrete aggregate productian record of the Yuba City-Marysville Praductian-Consumption Region for the years 1964-1984.**

YEAR	TOTAL AGGREGATE PRODUCTION (Tons)	PORTLAND CEMENT CONCRETE (PCC) PRODUCTION (Tons)	% PCC OF TOTAL
1964	711,000	202,000	28
1965	601,000	211,000	35
1966	624,000	223,000	36
1967	914,000	212,000	23
1968	553,000	161,000	29
1969	488,000	**	
1970	529,000	76,000	14
1971	463,000	96,000	21
1972	601,000	150,000	25
1973	431,000	133,000	31
1974	661,000	192,000	29
1975	529,000	188,000	36
1976	489,000	162,000	33
1977	612,000	**	
1978	835,000	184,000	22
1979	1,084,000	338,000	31
1980	966,000	345,000	36
1981	845,000	**	
1982	746,000	125,000	17
1983	716,000	**	
1984	864,000	350,000	41

*os reparted by the Bureau of Mines
**information nat avoilable

Average Annual Percent PCC Praduction = 28.6

Potential Alluvial PCC-Grade Aggregate

Alluvium classified MRZ-3 includes Tertiary and Quaternary river channel deposits in the Yuba City-Marysville area. Alluvium is considered desirable as PCC-grade aggregate because of its roundness and ease of mining. Although unlikely due to the large reserves, future PCC-grade aggregate needs in the P-C region may require a transition from the mining of premium quality alluvial materials in MRZ-2 areas to the mining of an inferior grade alluvium that requires more extensive and costly processing.

Potential Crushed Rock Aggregate

Crushed stone from massive consolidated rock formations may provide an alternative to natural alluvial deposits. Large areas classified MRZ-3 in the eastern portion of the Yuba City-Marysville P-C Region contain potential PCC-grade aggregate.

To the east of the Yuba City-Marysville P-C Region is the Sierra Nevada Mountain range. Massive amounts of metasedimentary and metavolcanic greenstone exist there that may meet crushed PCC-grade aggregate specifications. These deposits are commonly located in regions where little or no PCC-grade aggregate is currently produced.

At the present time, however, economic considerations indicate that crushed rock cannot compete with alluvial PCC-grade aggregate resources that are available in the Yuba City-Marysville P-C Region.

YUBA CITY-MARYSVILLE AS AN ALTERNATIVE RESOURCE

The long-term aggregate needs of the Yuba City-Marysville P-C Region will be easily satisfied from local sources, and exports are likely to increase as aggregate resources of the nearby urban areas become depleted (i.e., Sacramento and San Francisco). Sacramento lies about 45 miles south of the Yuba City-Marysville P-C Region. DMG Special Report 156 (Dupras, 1985), indicates that the Sacramento-Fairfield P-C Region could deplete its aggregate resources as soon as mid-1991. San Francisco lies about 125 miles southwest of the Yuba City-Marysville P-C Region. CDMG Special Report 146 (Stinson and others, 1983) indicates that the South San Francisco Bay area could deplete its aggregate resources as soon as 1999. As the aggregate resources in these large urban areas are depleted, the Yuba City-Marysville aggregate resources may become a more important source of supply to the Sacramento area and an important alternative source for the South San Francisco Bay area.

In recognition of potential shortages of aggregate in these major market areas, several studies have been conducted on the problems and costs of transporting aggregate from Yuba City-Marysville to San Francisco and Sacramento.

Barges

The U.S. Army Corps of Engineers has researched the possibility of constructing a shallow-draft channel for the transport of aggregate by barge from the Yuba River/Feather River areas to the San Francisco Bay area. The study develops benefits estimated for a shallow-draft channel, 12 feet deep with a 225-foot bottom width with side slopes of 1 vertical to 4 horizontal. The channel would be built from Sacramento to Nicolaus and later to near Olivehurst by deepening existing channels and/or constructing a new channel (Figure 13). Aggregate would be loaded onto barges at a terminal at Nicolaus or near Olivehurst after being moved by conveyor belt from the Yuba River area, and moved by towboat to Sacramento through the new canal system. From there the barge tows would utilize the William G. Stone Lock at Sacramento and the Sacramento Deep-Water Ship Channel route to the Bay area. Approximately 10,350 tons of aggregate would be transported by each barge tow of seven barges. (U.S. Department of the Army, Corps of Engineers, 1977, transportation economic studies.)

Since there are no existing PUC rates applicable to barge transportation on the proposed waterway, a detailed study of barge line-haul operation and rates on comparable existing waterways was made to develop probable barge rates for transporting the Feather River and Yuba River aggregates. The study included detailed analyses of published barge rates, average operating costs of barges and towboats, new equipment cost data, unregulated barge rates for contract shipments, and other data pertinent to constructing barge rates. The barge rates were estimated using barge tows of sufficient size to move the prospective commerce with reasonable convenience and safety. The barge rates developed were combined with mining and processing costs, overland haul costs to barge terminal (conveyor-belt or slurry pipeline), terminal charges, and transfer and redistribution costs to obtain estimates of the delivered price of Feather River and Yuba River aggregates to Bay area markets (U.S. Department of the Army, Corps of Engineers, 1977, transportation studies). A cost analysis, from that 1977 study (Table 7), shows that barged aggregate could be delivered to the the South San Francisco Bay area for $6.59 per ton if the waterway was already built.

Unit Trains

Another transportation method which was investigated by the U.S. Army Corps of Engineers was the already existing railroad system. Existing train tracks lie approximately 9 miles to the west of the Yuba River dredge field (Sector A). With an additional track construction to link the dredge field area to the existing railhead, and cooperation with the railroad operators, railroad transportation could be utilized. The aggregate resource could be transported by the unit train system.

Several efficiencies can be realized from unit train operations. This has led to an increase in their use, nationally, for movement of coal, containers and grain. Fuel efficiency is achieved by moving large quantities of a single commodity, or containerized commodities, from one organization point to a single destination. Operational efficiencies are realized since equipment is utilized efficiently, and switching, coupling and other train operations are minimized (California Department of Transportation, 1972).

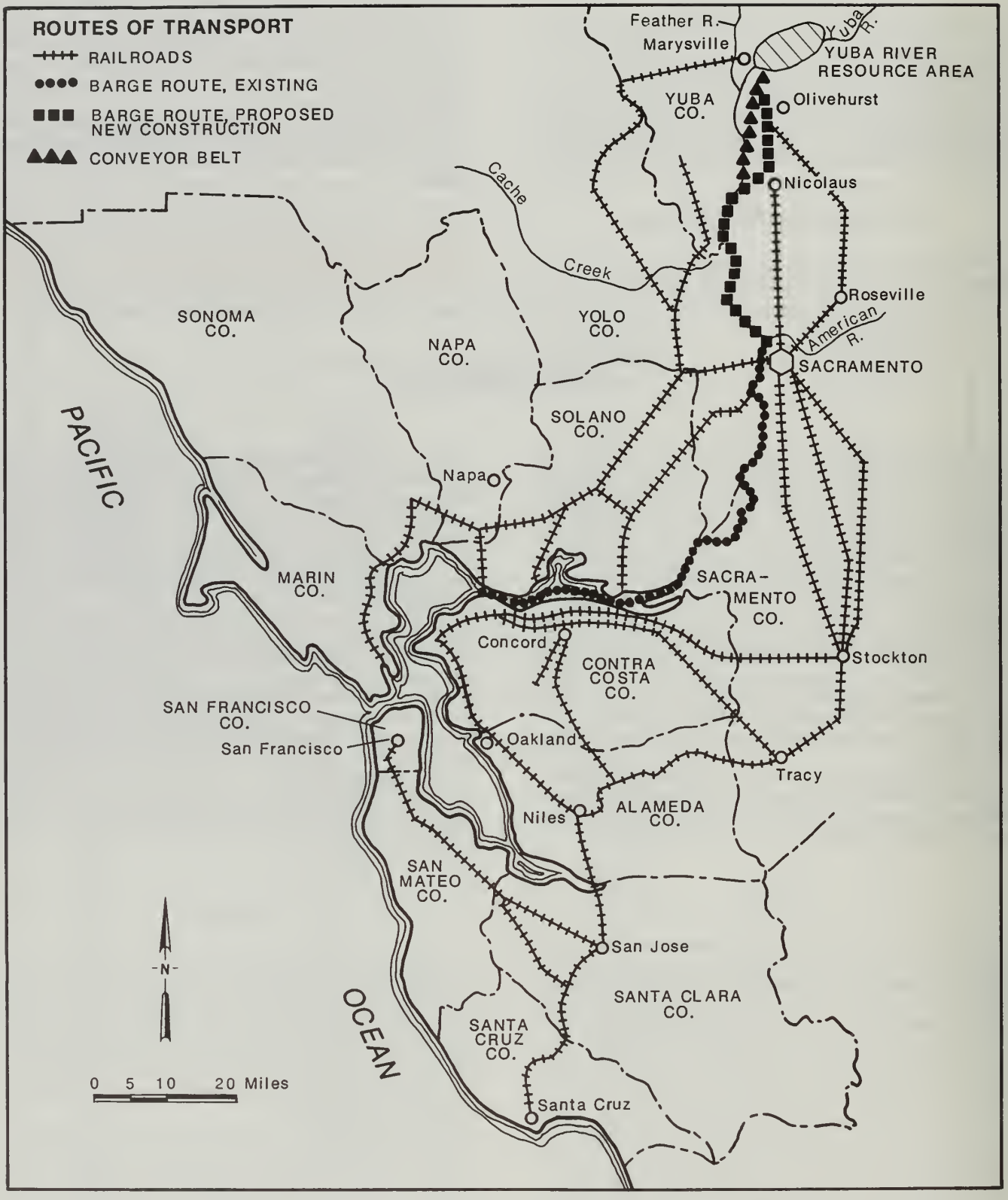

Figure 13. Proposed transport routes of aggregate by barge and railroad from the Yuba River resource area to the San Francisco Bay area.

Based on the consideration that unit trains will be used to some extent in transporting aggregates in the future, an analysis by the U.S. Army Corps of Engineers was made of unit train rates from various sources of supply to the market areas under consideration. This type of train — generally consisting of 70-100 cars with a capacity of 100 tons each — is assigned specifically for loading at one origin, unloading at another single destination each trip, and moving in both directions on a predetermined schedule. On the basis of preliminary analysis it was evident that the granitic rock deposits near Watsonville, the Tertiary Gravels in Nevada and Placer counties, the alluvial channel deposits of the Feather River, and the Yuba River dredge field would be the primary sources of supply for potential unitized train movements to San Francisco Bay area markets. Accordingly, estimated unit-train rates were developed for these movements.

Rates for unit-train haulage are negotiated on the basis of long-term contracts between the railroad and the shipper. The rate will be influenced by competitive factors if two railroads are competing for the unit-train traffic itself or for other traffic generated by the shipper. The ability of the railroad to absorb the traffic will be a consideration, based on such interrelated factors as road-bed grade, density of traffic, interference with high-rate freight trains, and terminal congestion. A cost analysis, which was generated in 1977, can be found on Table 8 (U.S. Department of the Army, Corps of Engineers, 1977, transportation studies).

Trucks

The third and most economical method of transportation at this time is the truck. It is estimated that in 1985 approximately one million tons of PCC-grade aggregate was trucked into the Sacramento area from the Yuba River. At this time, however, it does not appear to be economical to transport anything but specialty aggregate to the San Francisco Bay area. Using the PUC distance rate (MRT-7A, Nov. 1985), the trucking costs to the San Francisco area would be approximately $12 per ton. As the low-cost aggregate resources in and near the Bay area and Sacramento begin to run out, the trucking of distant aggregate will become more competitive with higher-cost local sources.

*TABLE 7.** Estimated delivered price of aggregotes per tan in the San Francisco Bay area from the Yuba River depasit using barge transportation* (1977 data).*

YUBA RIVER (Hammonton) — to —	North Bay	East Bay	West Bay	South Bay
Mining and processing	$2.450	$2.450	$2.450	$2.450
Overland haul of 22 miles ta Nicalaus barge terminal (canveyar-belt)	1.000	1.000	1.000	1.000
Terminal charges (laading, unlooding, etc.)	0.750	0.750	0.750	0.750
Line-haul charge (barge)	0.888	1.131	1.166	1.312
Transfer and distributian	0.910	0.690	0.570	1.080
TOTAL PER TON	$5.998	$6.021	$5.936	$6.592

* Estimotes bosed on an improved channel ta Nicalaus by 1998 with conveyar-belt to Hammonton (Plan G alignment).

** Tobles 7 and 8 were derived fram the U.S. Army Engineer District, Corps of Engineers, Sacromento, Califarnia. "Transpartation Economic Studies Sacramenta Valley Navigation, Califarnia," Octaber 1977. This data wos generoted in 1977 and does not reflect current prices, but is used os a guide for casts.

*TABLE 8.** Estimated delivered price of aggregates per ton in the San Francisco Bay Area fram the Yuba River depasit using rail transportation (1977 data).*

YUBA RIVER (Hammonton) — to —	North Bay	East Bay	West Bay	South Bay
Mining and processing	$2.450	$2.450	$2.450	$2.450
Overland haul af 9 miles to rail terminal (canveyar-belt)	0.405	0.405	0.405	0.405
Terminal charges (looding, unloading, etc.)	0.550	0.550	0.550	0.550
Line-haul charge	1.973	2.490	3.105	2.898
Tronsfer ond distributian	0.910	0.690	0.570	0.570
TOTAL PER TON	$6.288	$6.585	$7.080	$6.873

** Tables 7 and 8 were derived from the U.S. Army Engineer District, Carps of Engineers, Sacromenta, Califarnia. "Transpartatian Economic Studies Sacramenta Valley Navigotian, Califarnio," Octaber 1977. This data was generoted in 1977 and daes nat reflect current prices, but is used as a guide for costs.

CONCLUSIONS

The estimated total amount of available PCC-grade aggregate resources in the 145-square-mile Yuba City-Marysville Production-Consumption Region is 2.3 billion tons. These resources, in areas classified MRZ-2, are located within two sectors, A and B, which are subdivided into 18 subsectors. The total area covered by these sectors is approximately 23 square miles.

Based on the projected population growth and the calculated average annual per capita consumption rate of 5.4 tons per person determined for the years 1964-1984, approximately 26.5 million tons of aggregate would be needed for the Yuba City-Marysville P-C Region to meet its local needs to the year 2035. This is well below the current reserve tonnage of 1.26 billion tons that the study area contains. Thus, the reserves that are contained within the Yuba City-Marysville P-C Region are more than adequate to supply the urbanizing area with PCC-grade aggregate for the 50-year foreseeable future. Because of the large volume of PCC-grade aggregate in Yuba City-Marysville, these resources should be seriously considered as alternative resources for the large market regions in the Sacramento and San Francisco Bay areas. There are significant exports of aggregate to the Sacramento area at present and an increase is likely in the future.

ACKNOWLEDGMENTS

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APPENDIX A

Interim Criteria for Sectorization of MRZ-2 Areas for Aggregate

The purpose of sectorizing MRZ-2 areas is to provide a semi-quantified estimate of construction aggregate resources which are likely to be available to satisfy society's needs during the next 50 years. This estimate, when compared to DMG projected needs for the next half century, provides the context for communities to plan for future resource availability in their land-use policies. The determination of sectors is intended for the use of the State Mining and Geology Board in identifying areas which are candidates for designation under SMARA. The development of sectors provides a perception of future mineral resource availability in the face of future needs and also portrays where these available minerals are generally located. This information is distributed by the Board to all affected lead agencies to provide them with the data necessary to plan for future resource availability in their land-use policies.

Areas within MRZ-2 classifications are sectorized if they have current land uses which are similar to those in areas which have undergone mineral extraction in the past. Areas within MRZ-2 classifications which have generally not been available for surface mining in the past for specified social or economic reasons are not sectorized. Since such areas are unlikely to be used for surface mining during the foreseeable future, their inclusion in estimates of future resource availability would be misleading.

The estimation of future mineral resource availability in sectors is not a precise analysis, but rather is the best general estimate which can be made with the data presently available. Areas within and without sectors, can be used for mining or other land uses at the discretion of the local governments which are charged with responsibility for making land-use decisions. Establishment of sectors in no way infringes on this authority. Rather, it provides a perception of future mineral resource availabilities in the face of future needs and also portrays where these available minerals are generally located.

The following criteria are used by DMG in identifying mineral resource areas which are available for future use. These criteria, in conjunction with the geologic and geometric characteristics of specific mineral deposits are used in sectorizing MRZ-2 areas. Use of these criteria assure that sectors contain geologically homogeneous mineral deposits which, based upon current land use, will be available for future use.

The following specific land uses are considered to be generally incompatible with mining and have been excluded from sectored lands. Mineral resource areas containing land uses not specifically listed will be considered for sectorization. The criteria are to be applied only to lands classified as MRZ-2.

There are two general categories of exclusion: I) Economic Exclusion, and II) Social Exclusion.

I) *Economic Exclusion*

Specific excluded land uses are:

1) Residential areas,
2) Commercial areas with land improvements (buildings),
3) Industrial areas (buildings and adjacent needed storage and parking facilities), and
4) Major public or private engineering projects, including:
   a) canals
   b) freeways
   c) bridges
   d) airports and associated developments such as parking lots
   e) dams
   f) railroads
   g) major pipelines
   h) major power transmission lines

II) *Social Exclusion*

Specific excluded land uses are:

1) Cemeteries,
2) Geologic Scientific Zones,
3) Public parks, developed historical sites and structures, and public recreation areas of all types,*
4) Public or private schools, institutions, hospitals, and prisons, including adjacent grounds and related structures, and
5) Military bases and reservations.

* NOTE: Since the development of these interim criteria, a policy change regarding parklands has occurred. Parklands are now sectarized if they are not excluded on the basis of economic criteria. Sectarized parklands are however, treated separately in the classification reports, and their mineral resources are not mixed with those occurring on other types of land.

APPENDIX B

Gradation of Aggregate from the Yuba River Dredge Tailings*

Sieve	Percent Passing		
	Sand, Processed	Coarse Aggregate	
		Pit Run	Used in Mix
6-in.		100	
5-in.		98	
4-in.		93	100
3-in.		82	83
2½ in.		73	73
2-in.		66	63
1½ in.		56	50
1-in.		36	35
3/4 in.		26	27
1/2 in.		14	17
3/8 in.	100	8	10
No. 4	96	2	0
No. 8	77		
No. 16	61		
No. 30	39		
No. 50	12		
No. 100	3		
Decant Loss (–#200)	0.5		
Fineness Modulus	3.12		

(a) Wet Sieve (CRD-C-105)

* From U.S. Department of the Army, Corps of Engineers, Aggregate Investigation for Marysville Lake Project, Yuba River, California, 1974, unpublished.

APPENDIX C

Composition of Fine Aggregate in the Yuba River Dredge Tailings*

ROCK TYPES, PERCENT	Sieve Size				
	No. 8	No. 16	No. 30	No. 50	No. 100
Volcanic	33	27	23	19	14
Vein Quartz	30	24	18	9	2
Quartzite	21	14	8	5	3
Metavolcanic	7	4	1	1	—
Granite	5	3	2	2	1
MINERAL TYPES, PERCENT					
Quartz	3	20	35	42	47
Feldspar	1	8	13	20	26
Mica		tr.	tr.	1	3
Hornblende			tr.	1	2
Magnetite				tr.	2
Sphene					tr.
Total	100	100	100	100	100

* From U.S. Department of the Army, Corps of Engineers, Aggregate Investigation for Marysville Lake Project, Yuba River, California, 1974, unpublished.

APPENDIX D

Composition of Coarse Aggregate in the Yuba River Dredge Tailings*

ROCK TYPES, PERCENT	+3-in.	1½-in. to 3-in.	3/4 in. to 1½-in.	No. 4 to 3/4-in.
Volcanic	50	49	49	45
Quartzite	18	19	18	18
Metavolcanic	12	11	12	15
Vein Quartz	—	3	9	14
Granite	20	18	12	8
Chert	tr.	tr.	tr.	tr.
Total	100	100	100	100

*From U.S. Department of the ARmy, Corps of Engineers, Aggregate Investigation for Marysville Lake Project, Yuba River, California, 1974, unpublished.

APPENDIX E

Concrete Aggregate Test Data from the Yuba River Dredge Tailings* (Teichert Aggregate Hallwood Plant)

	SPECIFIC GRAVITY SSD	ABSORPTION %	L.A. ABRASION % LOSS	SULFATE SOUNDNESS % LOSS	DECANTION %	MORTAR STRENGTH 7 DAY	MORTAR STRENGTH 28 DAY	ORGANIC IMPURITIES
Coarse Aggregate								
No. 4-3/4"	2.72	1.4	Class "A"	15				
3/4" to 1½"	2.77	1.0	25	7				
1½" to 3"	2.78	0.7	Class "I"					
3" to 6"	2.77	0.9	10					
Fine Aggregate	2.67	1.1	—	16	0.5	1.48	1.49	Satisfactory (from Goldman, 1961, p. 33)
Test Method (and minimum PCC-grade aggregate standard as set by Caltrans)	CRD C-107 & 108 (>2.60)	CRD C-107 & 108 (<1)	CRD C-117 (>45)	CRD C-115 (<10)	CRD C-105	CRD C-116 (>.95)		CRD C-121 (Satisfactory)

Freezing & Thawing Test method CRD C-114, (minimum Caltrans standard — 65%)
Relative Dynamic Modulus of Elasticity at 300 Cycles 35% 50% 19% (average 35%)

Mortar Bar Expansion Test method CRD C-123

	Length Change	(minimum Caltrans standard)
Low Alkali Cement	0.001%	(less than 0.10%)
High Alkali Cement	0.011%	(less than 0.80%)

*Adopted from U.S. Department of the Army, Corps of Engineers, Aggregate Investigation for Marysville Lake Project, Yuba River, California, 1974, unpublished.

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MINERAL LAND CLASSIFICATION: PORTLAND CEMENT CONCRETE-GRADE AGGREGATE IN THE YUBA CITY-MARYSVILLE PRODUCTION-CONSUMPTION REGION

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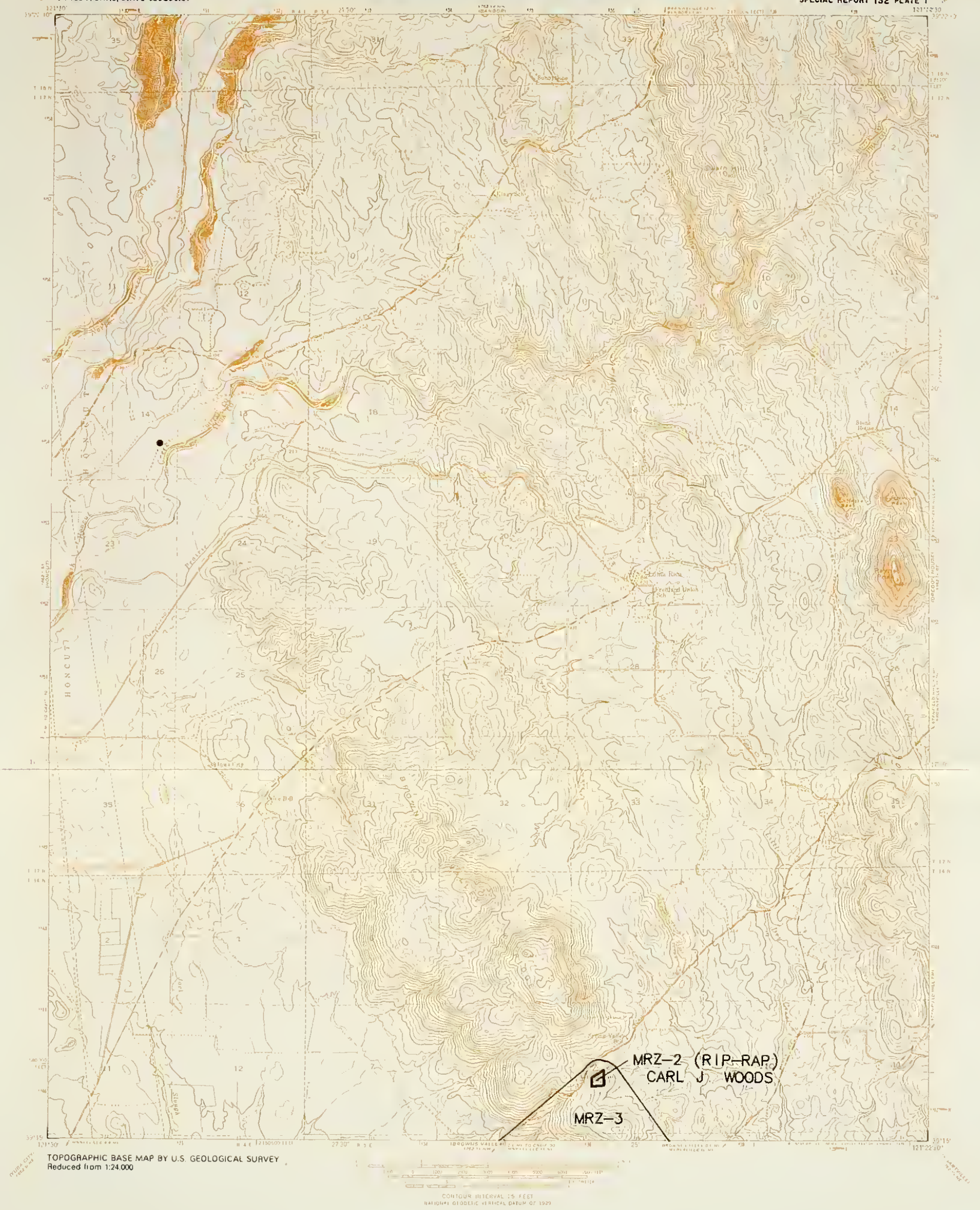
LOMA RICA QUADRANGLE

SPECIAL REPORT 132 PLATE 1



TOPOGRAPHIC BASE MAP BY U.S. GEOLOGICAL SURVEY
Reduced from 1:24,000

CONTOUR INTERVAL 25 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

LOMA RICA, CALIF.

MINERAL LAND CLASSIFICATION MAP

YUBA CITY - MARYSVILLE PRODUCTION - CONSUMPTION REGION

(Portland Cement Concrete Grade Aggregate Resources Unless Otherwise Indicated)

By
Robert Hobel and Linda Compton

1986

PREPARED IN COMPLIANCE WITH THE SURFACE MINING AND RECLAMATION ACT OF 1975, ARTICLE 4, SECTION 2761

STATE GEOLOGIST MAY 30, 1987

EXPLANATION

PRODUCTION-CONSUMPTION REGION BOUNDARY AND OUTER BOUNDARY OF AREAS SUBJECT TO URBANIZATION AND LIMIT OF AREA CLASSIFIED
Boundaries established from data supplied by the Office of Planning and Research with modifications developed from information supplied by local government and other sources.

MRZ-2

MINERAL RESOURCE ZONE BOUNDARIES
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See text for additional explanation of MRZ Symbols.

N

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SUTTER QUADRANGLE

SPECIAL REPORT 132 PLATE 2

TOPOGRAPHIC BASE MAP BY U.S. GEOLOGICAL SURVEY
Reduced from 1:24,000

CONTOUR INTERVAL 5 FEET

SUTTER, CALIF.

EXPLANATION

DRILL HOLE

● Data indicates possible aggregate resources

○ Data indicates little likelihood for aggregate resources

PRODUCTION-CONSUMPTION REGION BOUNDARY AND OUTER BOUNDARY OF AREAS SUBJECT TO URBANIZATION AND LIMIT OF AREA CLASSIFIED
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MINERAL LAND CLASSIFICATION MAP

YUBA CITY - MARYSVILLE PRODUCTION - CONSUMPTION REGION

(Portland Cement Concrete Grade Aggregate Resources Unless Otherwise Indicated)

By
Robert Habel and Linda Campian
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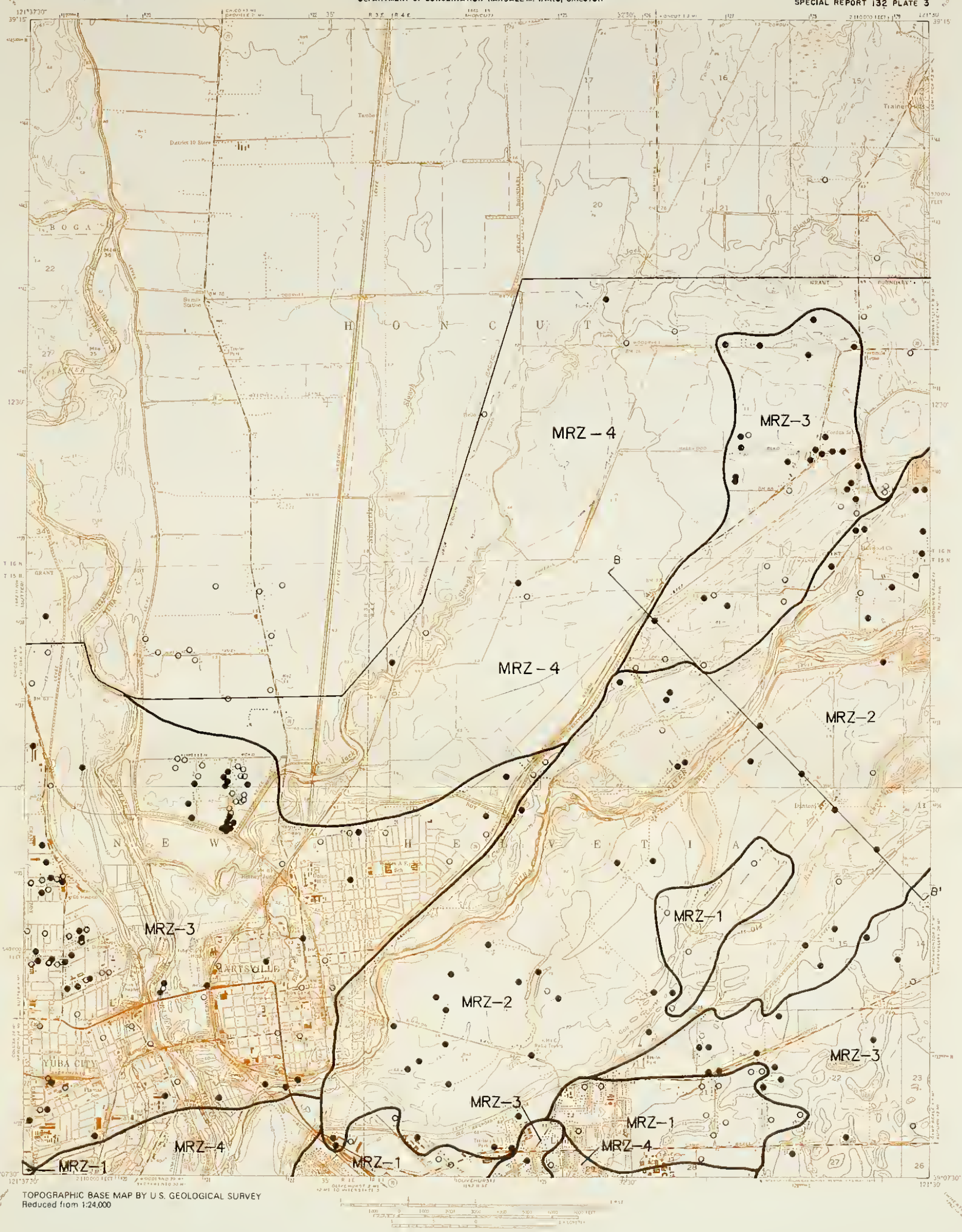
YUBA CITY QUADRANGLE

SPECIAL REPORT 132 PLATE 3



TOPOGRAPHIC BASE MAP BY U.S. GEOLOGICAL SURVEY
Reduced from 1:24,000

CONTOUR INTERVAL 5 FEET
CONTOURS INCOMPLETE ALONG EMBANKMENTS AND DITCHES
NATIONAL GEODETIC VERTICAL DATUM OF 1929

YUBA CITY, CALIF.

EXPLANATION

DRILL HOLE

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YUBA CITY - MARYSVILLE PRODUCTION - CONSUMPTION REGION

(Portland Cement Concrete Grade Aggregate Resources Unless Otherwise Indicated)

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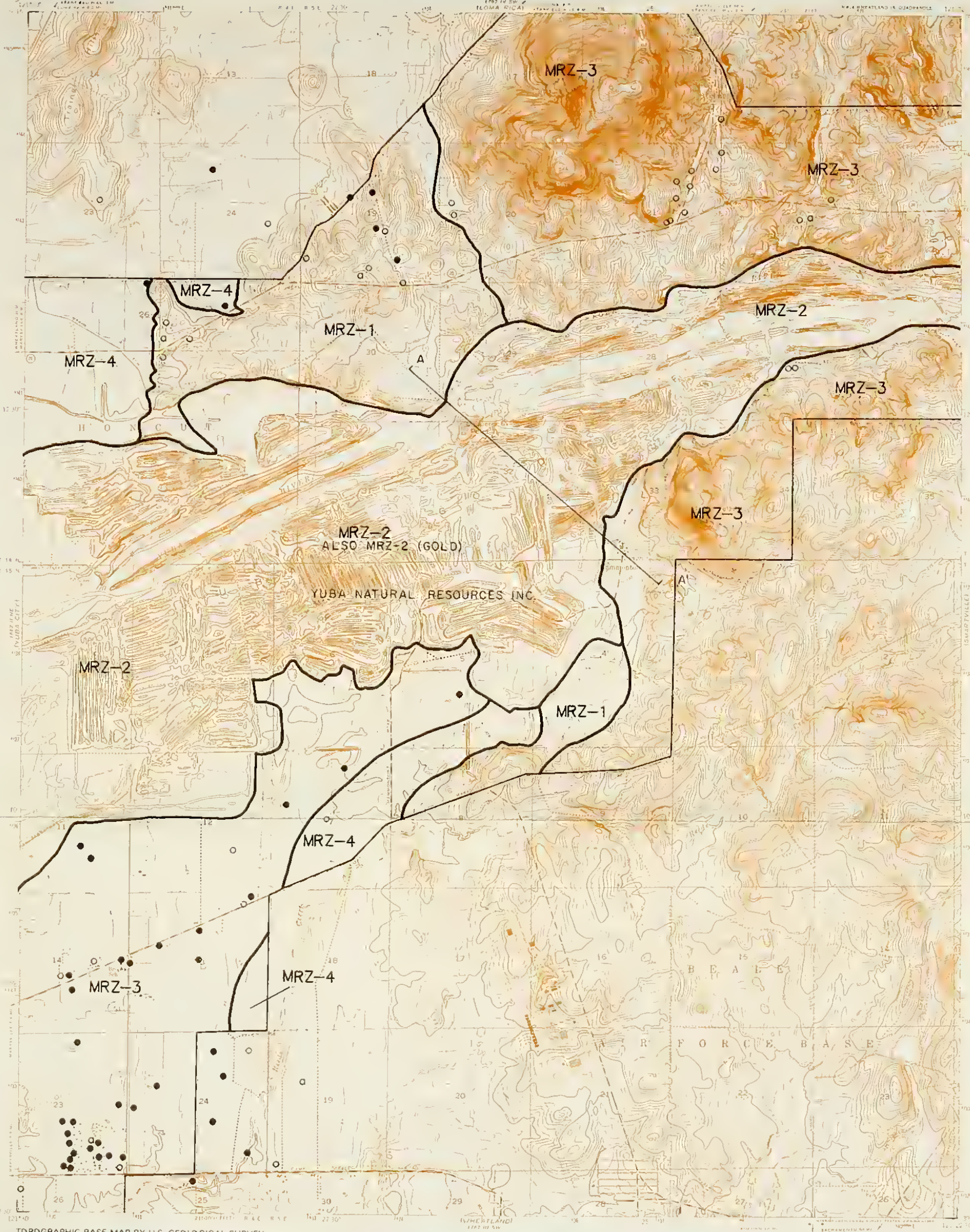
BROWNS VALLEY QUADRANGLE
SPECIAL REPORT 132 PLATE 4



TOPOGRAPHIC BASE MAP BY U.S. GEOLOGICAL SURVEY
Reduced from 1:24,000

CONTOUR INTERVAL 5 FEET
CONTOUR INTERVAL IN ENLARGED AREA 25 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

BROWNS VALLEY, CALIF.

EXPLANATION

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YUBA CITY - MARYSVILLE PRODUCTION - CONSUMPTION REGION

(Portland Cement Concrete Grade Aggregate Resources Unless Otherwise Indicated)

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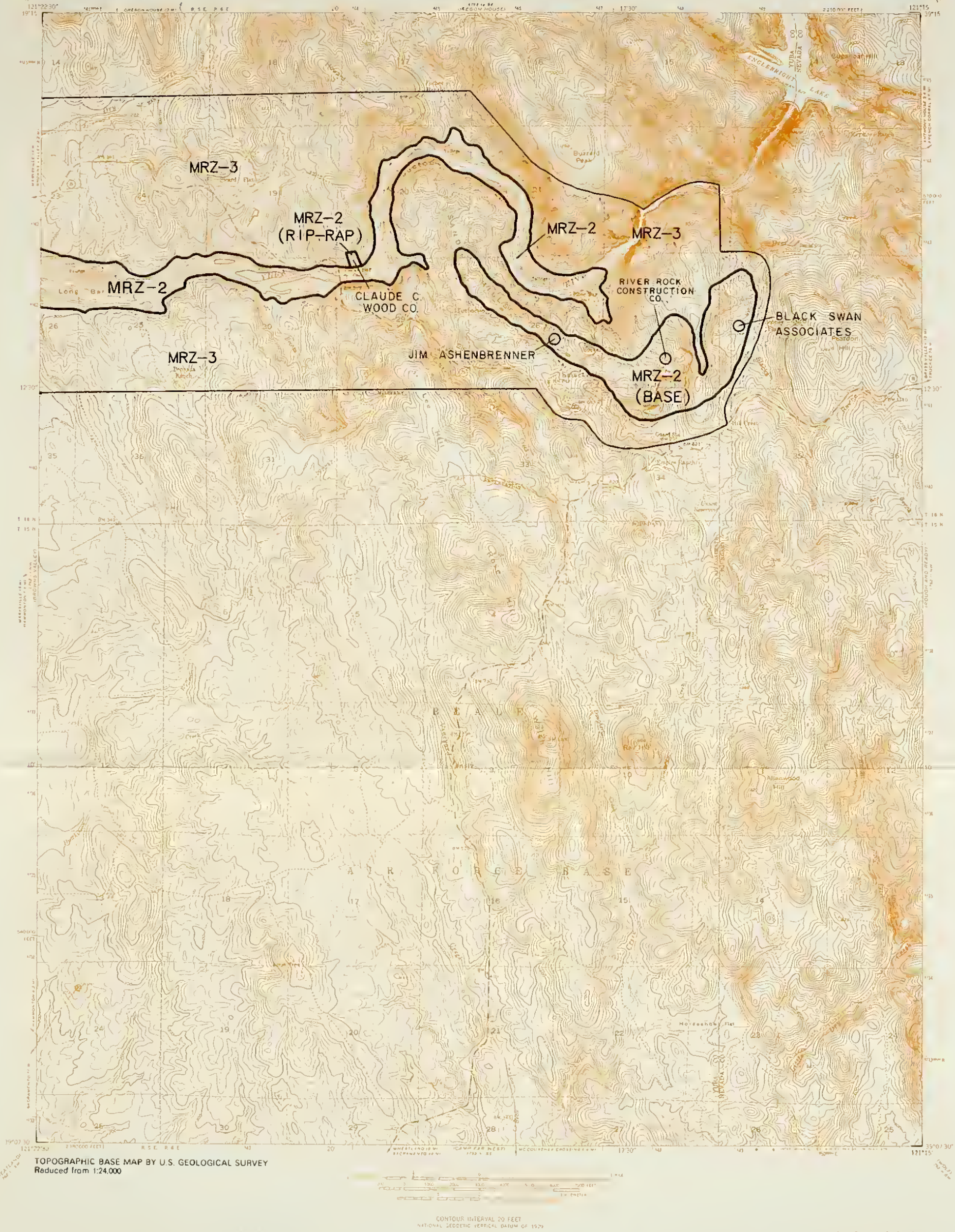
SMARTVILLE QUADRANGLE

SPECIAL REPORT 132 PLATE 5



TOPOGRAPHIC BASE MAP BY U.S. GEOLOGICAL SURVEY
Reduced from 1:24,000

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

SMARTVILLE, CALIF.

EXPLANATION

PRODUCTION-CONSUMPTION REGION BOUNDARY AND OUTER BOUNDARY OF AREAS SUBJECT TO URBANIZATION AND LIMIT OF AREA CLASSIFIED
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MINERAL LAND CLASSIFICATION MAP

YUBA CITY - MARYSVILLE PRODUCTION - CONSUMPTION REGION

(Portland Cement Concrete Grade Aggregate Resources Unless Otherwise Indicated)

By
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TOPOGRAPHIC BASE MAP BY U.S. GEOLOGICAL SURVEY
Reduced from 1:24,000

CONTOUR INTERVAL 5 FEET

GILSIZER SLOUGH, CALIF.

EXPLANATION

DRILL HOLE

- ● Data indicates possible aggregate resources
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PRODUCTION-CONSUMPTION REGION BOUNDARY AND OUTER BOUNDARY OF AREAS SUBJECT TO URBANIZATION AND LIMIT OF AREA CLASSIFIED
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YUBA CITY - MARYSVILLE PRODUCTION - CONSUMPTION REGION

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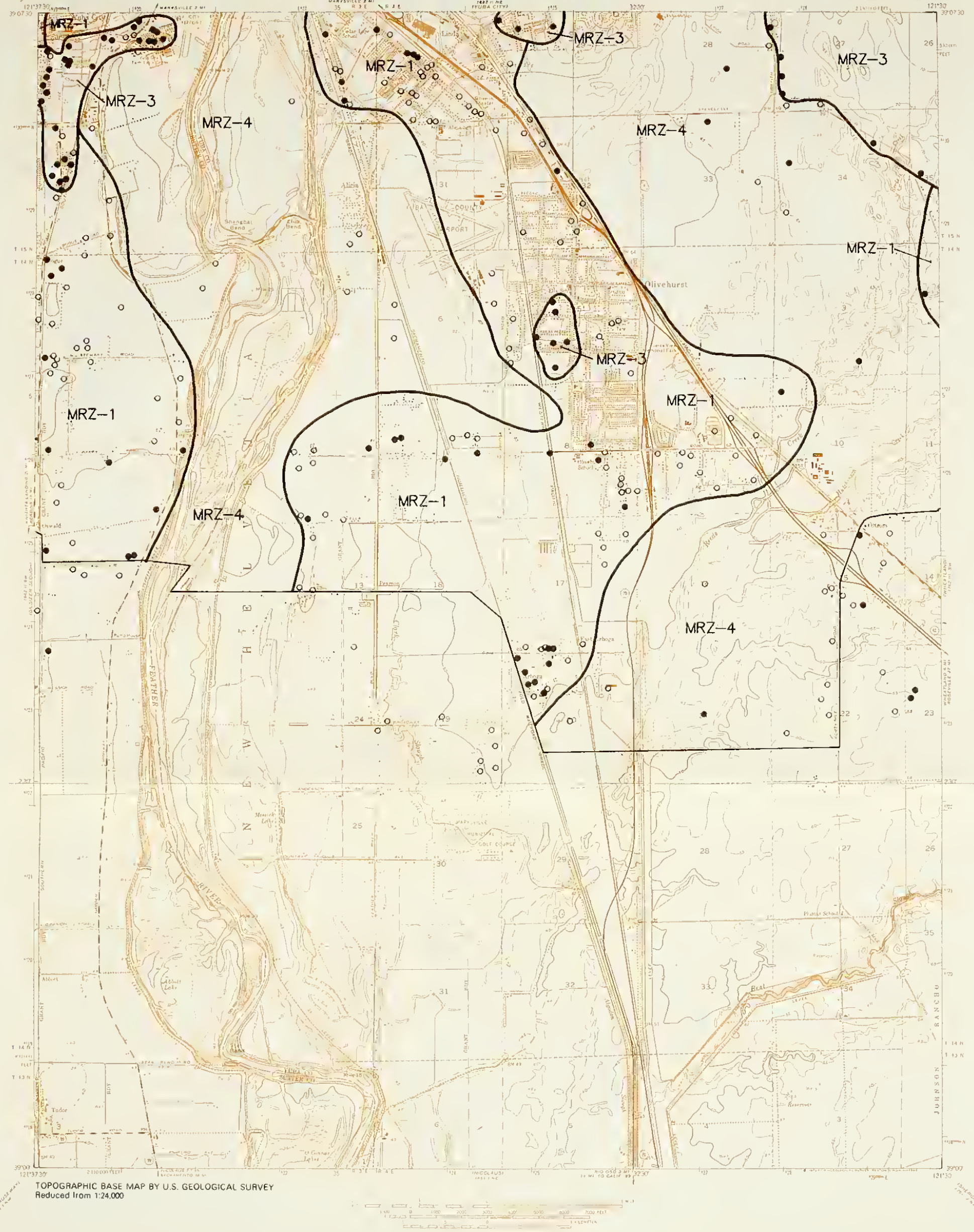
OLIVEHURST QUADRANGLE
SPECIAL REPORT 132 PLATE 7



TOPOGRAPHIC BASE MAP BY U.S. GEOLOGICAL SURVEY
Reduced from 1:24,000

CONTOUR INTERVAL 5 FEET
CONTOURS INCOMPLETE ALONG EMBANKMENTS AND DITCHES
NATIONAL GEODETIC VERTICAL DATUM OF 1929

OLIVEHURST, CALIF

EXPLANATION

DRILL HOLE

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PRODUCTION-CONSUMPTION REGION BOUNDARY AND OUTER BOUNDARY OF AREAS SUBJECT TO URBANIZATION AND LIMIT OF AREA CLASSIFIED
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MINERAL LAND CLASSIFICATION MAP

YUBA CITY - MARYSVILLE PRODUCTION - CONSUMPTION REGION

(Portland Cement Concrete Grade Aggregate Resources Unless Otherwise Indicated)

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JAMES F. DAVIS, STATE GEOLOGIST

WHEATLAND QUADRANGLE

SPECIAL REPORT 132 PLATE 8

TOPOGRAPHIC BASE MAP BY U.S. GEOLOGICAL SURVEY
Reduced from 1:24,000

CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

WHEATLAND, CALIF.

EXPLANATION

DRILL HOLE

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MINERAL LAND CLASSIFICATION MAP

YUBA CITY - MARYSVILLE PRODUCTION - CONSUMPTION REGION

(Portland Cement Concrete Grade Aggregate Resources Unless Otherwise Indicated)

By
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1986

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DEPARTMENT OF CONSERVATION–RANDALL M. WARD, DIRECTOR

YUBA CITY QUADRANGLE

SPECIAL REPORT 132 PLATE 9

AGGREGATE OPERATORS

BC – Baldwin Contracting Co.
CA – Centex Aggregates,Inc.
LS – Linda Sand and Gravel Co.
QI – Quinco, Inc.
TI – Trinco, Inc.

SECTOR A–1 BC
SECTOR B–8
SECTOR B–9
TI
SECTOR B–8
TI
SECTOR A–1
TI
CA
NOT IN SECTOR
SECTOR B–5
SECTOR B–7
SECTOR B–6
SECTOR B–4
QI
SECTOR B–2
LS
SECTOR B–3
SECTOR B–1

TOPOGRAPHIC BASE MAP BY U.S. GEOLOGICAL SURVEY
Reduced from 1:24,000

CONTOUR INTERVAL 5 FEET

YUBA CITY, CALIF

EXPLANATION

Sector boundory

Properties owned or controlled by oggregote producers

N

PRODUCTION-CONSUMPTION REGION BOUNDARY AND OUTER BOUNDARY OF AREAS SUBJECT TO URBANIZATION AND LIMIT OF AREA CLASSIFIED
Boundaries established from data supplied by the Office of Planning and Research with modifications developed from information supplied by local government and other sources.

Aggregate Resource Sectors

Yuba City — Marysville P-C Regian

By
Robert Habel and Linda Campion

1986

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STATE GEOLOGIST MAY 30, 1987

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BROWNS VALLEY QUADRANGLE
SPECIAL REPORT 132 PLATE 1D

SECTOR A–3
SECTOR A–1
SECTOR B–8
SECTOR B–5
SECTOR A–7
SECTOR A–6
SECTOR A–5
SECTOR A–4
SECTOR A–2
SECTOR A–1 NOT IN SECTOR SECTOR B–7

TA
BC
YN
TI
CA
GS
PR

AGGREGATE OPERATORS

BC – Baldwin Contracting Co.
CA – Centex Aggregates,Inc.
GS – Garcia Sand and Gravel
PR – Placer Resources, Inc.
TA – Teichert Aggregates
TI – Trinco, Inc.
YN – Yuba Natural Resources, Inc.

TOPOGRAPHIC BASE MAP BY U.S. GEOLOGICAL SURVEY
Reduced from 1:24,000

CONTOUR INTERVAL 5 FEET
CONTOUR INTERVAL IN OFFSHORE AREA 25 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

BROWNS VALLEY, CALIF.

EXPLANATION

Sector boundary

Properties owned or controlled by aggregate producers

PRODUCTION-CONSUMPTION REGION BOUNDARY AND OUTER BOUNDARY OF AREAS SUBJECT TO URBANIZATION AND LIMIT OF AREA CLASSIFIED
Boundaries established from data supplied by the Office of Planning and Research with modifications developed from information supplied by local government and other sources

N

Aggregate Resource Sectors

Yuba City — Marysville P-C Region

By
Robert Habel and Linda Campion

1986

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SMARTVILLE QUADRANGLE

SPECIAL REPORT 132 PLATE II

GS

YN

YN

SECTOR A–7

SECTOR A–8

SECTOR A–9

AGGREGATE OPERATORS

GS – Garcia Sand and Gravel
YN – Yuba Natural Resources, Inc.

TOPOGRAPHIC BASE MAP BY U.S. GEOLOGICAL SURVEY
Reduced from 1:24,000

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

SMARTVILLE, CALIF.

EXPLANATION

Sector boundary

Properties owned or controlled by aggregate producers

N

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Aggregate Resource Sectors

Yuba City — Marysville P-C Region

By
Robert Hobel and Lindo Campion
1986

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DEPARTMENT OF CONSERVATION – RANDALL M. WARD, DIRECTOR

SPECIAL REPORT 132
PLATE 12

EXPLANATION

Quaternary Alluvial Deposits

Qal
- DT — dredge tailings
- Qsg — sand and gravel
- Qsm — sand and silt
- Qc — clay
- Qoa — older alluvium (Laguna Formation)

Bedrock Formations

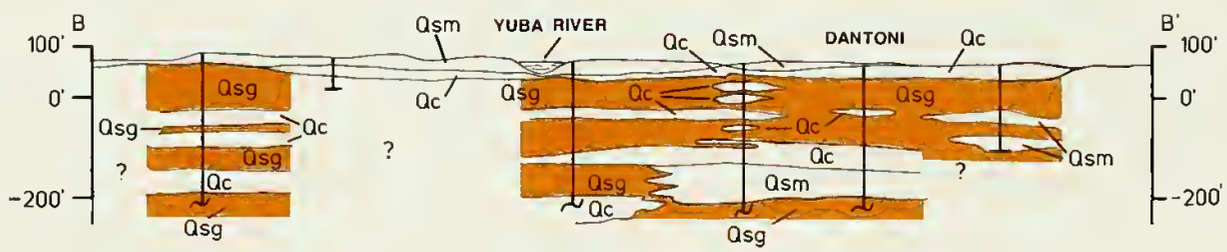
- Ti — Ione Formation, Eocene age
- JTrv — Metavolcanics and metasediments, Jurassic–Triassic age

SYMBOLS

- contact: dashed where inferred
- drill hole: wavy crossarm indicates bottom of hole is below cross-section limit
- geologic units suitable for use as PCC-grade aggregate (MRZ-2 areas)

200' / 100' / 0' — vertical exaggeration 8:1 — 0 / 1000' / 2000'

refer to Plates 3 and 4 for location of cross-section lines



MINERAL LAND CLASSIFICATION OF THE YUBA CITY–MARYSVILLE P–C REGION
GENERALIZED GEOLOGIC CROSS-SECTIONS A–A' AND B–B'

YUBA RIVER

by

Robert S. Habel

1986